1. *Answers should be written in continuous prose. Credit will be given for biological accuracy, the organisation and presentation of the information and the way in which the answer is expressed.*

The following extract has been taken from a dictionary of biological terms.

cell membrane: a membrane found either on the outside of a cell or within it. Cell membranes are extremely thin. They are only about 7 nm thick and so cannot be seen with a light microscope. A transmission electron microscope however shows a cell membrane consists of three lines forming a sandwich. The two outer lines are dark in colour while there is a lighter one in between. As it is impossible, even with an electron microscope, to see how the actual molecules are arranged in a cell membrane, it is necessary to produce a model to explain the membrane's properties. The most accurate model of membrane structure that has been developed is the fluid mosaic model and this can be used to describe most of the properties of a cell membrane. Cell membranes play a very important part in the biology of cells and they are particularly important in regulating the movement of substances into and out of cells.

Source: W.J.E. INDGE, The Complete A-Z Biology Handbook (Hodder & Stoughton) 1997

(a) (i) Describe the structure of a cell membrane.

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(5)

(ii) Describe **two** ways in which the appearance of a plant cell wall would differ from a cell membrane when viewed with an electron microscope.

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(2)

(b) Describe the part played by cell surface membranes in regulating the movement of substances into and out of cells.

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(6)

(c) Describe how the distribution of cell membranes in a prokaryotic cell such as a bacterium differs from that in a cell from a plant leaf.

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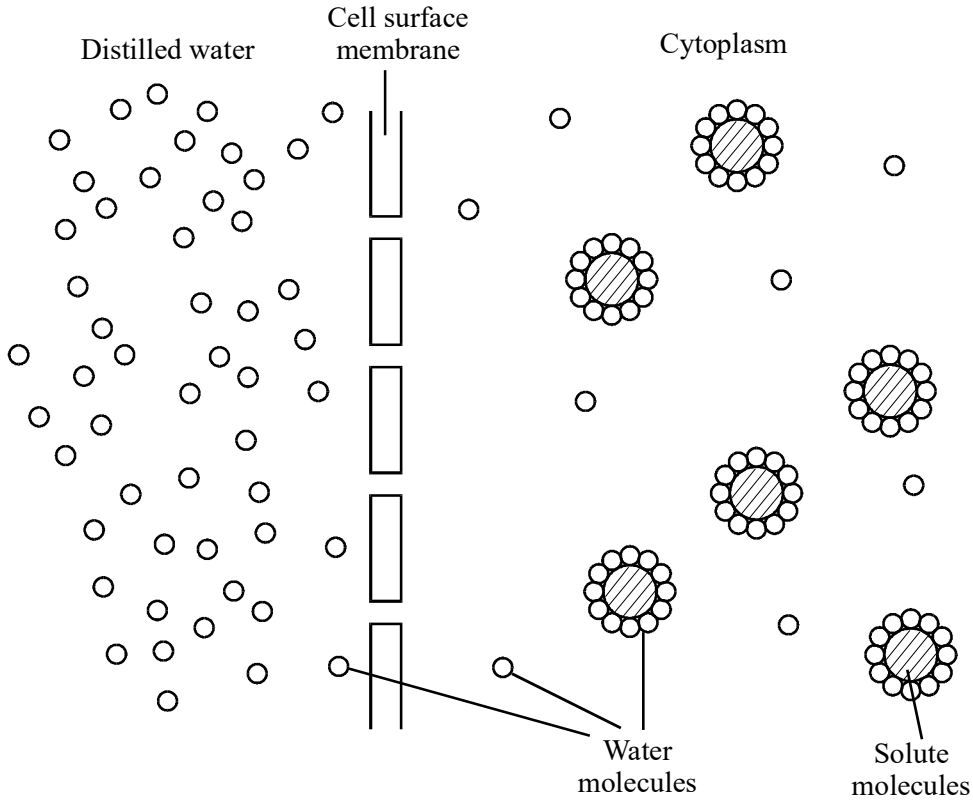
(4)
(QWC 3)
(Total 20 marks)

2. The diagram represents part of an animal cell which has been put in distilled water.



(a) Use the diagram to:

(i) explain why the water potential of the distilled water is higher than the water potential of the cytoplasm of the cell;

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(2)

(ii) describe the property of the cell surface membrane which allows osmosis to take place.

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(1)

(b) Osmosis has been described as a special case of diffusion. Describe **two** ways in which you would expect the movement of water into a cell by osmosis to be similar to the diffusion of oxygen into a cell.

1.....

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2.....

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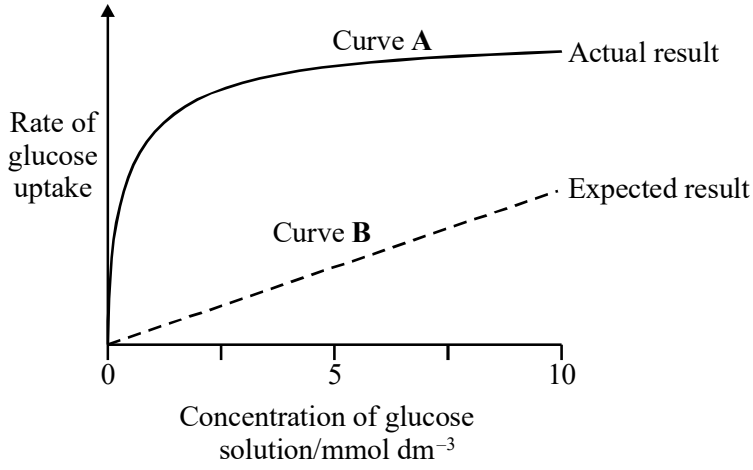
(2)
(Total 5 marks)

3. The graph shows the expected and actual results of an experiment to investigate the uptake of glucose by human red blood cells.



(a) Curve **B** shows the result that would be expected if glucose enters the red blood cells by simple diffusion.

(i) State Fick's Law.

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(1)

(ii) Explain how Curve **B** demonstrates one aspect of Fick's Law.

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(1)

(b) Curve **A** shows the results obtained from the red blood cells. It shows that these cells took up glucose by facilitated diffusion.
Explain the shape of the curve at glucose concentrations:

(i) less than 2 mmol dm^{-3};

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(2)

(ii) greater than 5 mmol dm^{-3}.

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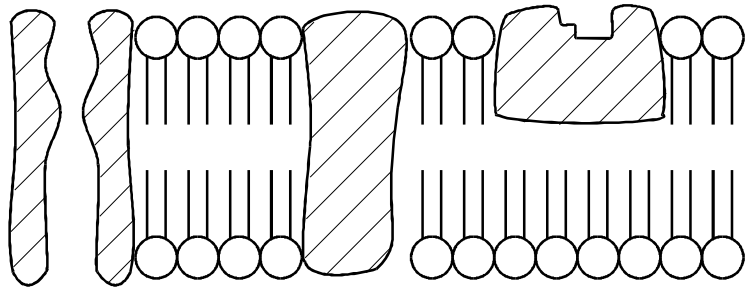
(1)
(Total 5 marks)

4. *Answers should be written in continuous prose. Credit will be given for biological accuracy, the organisation and presentation of the information and the way in which the answer is expressed.*

The diagram shows the arrangement of protein molecules in part of a cell surface membrane.



Key
Protein

(a) Explain how amino acid molecules may be linked to form a polypeptide chain which is folded into a specific tertiary shape.

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(6)

(b) Describe the role of proteins in the transport of molecules and ions across cell surface membranes.

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(7)

(c) The hormone glucagon is a protein. It targets liver cells but does not affect other cells in the body. Explain why.

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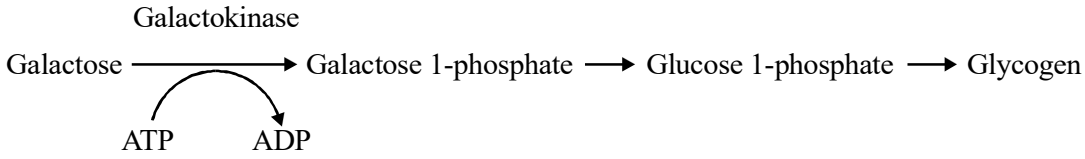
(4)

(Total 17 marks)

5. (a) Galactose is a monosaccharide. The diagram shows the biochemical pathway by which cells convert galactose to glycogen. The enzyme galactokinase catalyses the reaction in which galactose is converted to galactose 1-phosphate.



(i) Why is galactokinase classified as a *transferase*?

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(1)

(ii) Galactokinase is specific to the reaction shown. What features of the enzyme and substrate would contribute to this specificity?

Feature of enzyme

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Feature of substrate

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(2)

(b) Some people who have a deficiency of galactokinase suffer from cataracts. These cataracts result from an increase in the amount of water in the lens of the eye. In the absence of galactokinase, galactose is converted to galacticol. Galacticol is a soluble substance whose molecules are too large to pass through cell membranes. Explain why galacticol causes an increase in the amount of water in the lens of the eye.

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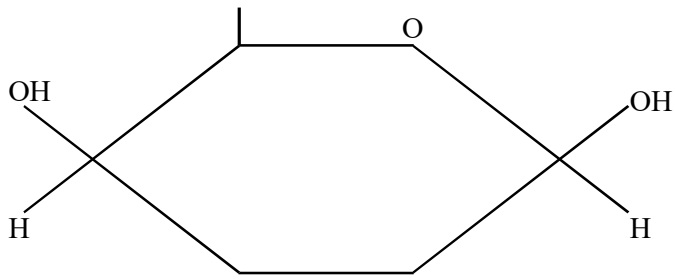
(2)

(c) The diagram shows the structure of a galactose molecule.



(i) Lactose is formed when glucose and galactose are joined by a glycosidic bond. Describe **one** similarity between the formation of the glycosidic bond and the formation of a peptide bond between two amino acids.

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(1)

(ii) Deduce the chemical formula for lactose.

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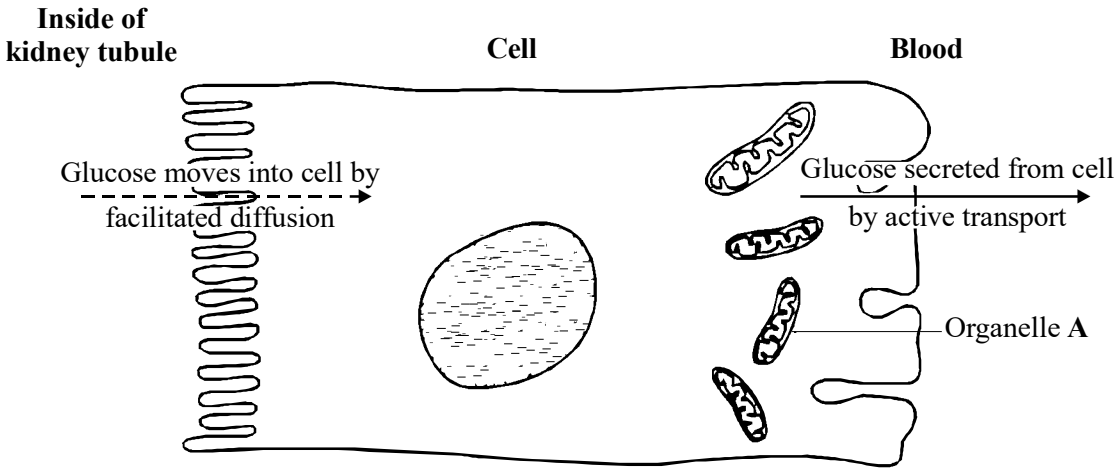
(1)

(d) Galactose is a component of some glycoproteins. These are proteins with carbohydrate units attached and form parts of cell membranes. The carbohydrate units are always found on the outside of the cell surface membrane.

Draw a labelled diagram of the cell surface membrane to show the phospholipids and a transmembrane (intrinsic) glycoprotein molecule.

(3)
(Total 10 marks)

6. A kidney consists of a large number of very small tubes called kidney tubules. Some of the cells which line these tubules are able to absorb glucose. The diagram shows how these cells absorb glucose from the contents of the tubule and secrete it into the blood.



(a) Glucose moves into the cell by facilitated diffusion. Osmosis also takes place across the plasma membrane.
Give **two** differences between facilitated diffusion and osmosis.

1.....

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2.....

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(2)

(b) Explain the link between active transport and the presence of large numbers of the organelles labelled **A** in this cell.

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(3)

(c) Explain **two** ways, shown in the diagram, in which the structure and activities of this cell ensure efficient absorption of glucose from the inside of the kidney tubule.

1.....

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2.....

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(2)
(Total 7 marks)

7. (a) Describe a chemical test you could carry out to show that a piece of coconut contains lipids.

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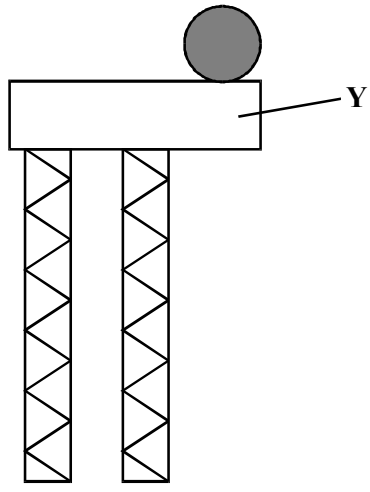
(3)

(b) The diagram shows the structure of a phospholipid molecule,



(i) Name the part of the molecule labelled Y.

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(1)

(ii) Describe how a phospholipid molecule differs in structure from a triglyceride molecule

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(1)

(iii) Chitin is a nitrogen-containing polysaccharide. Name **one** chemical element present in a phospholipid which would not be present in chitin.

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(1)

(c) An artificial membrane was made. It consisted only of a bilayer of phospholipid molecules. In an investigation, the permeability of this artificial membrane was compared with the permeability of a plasma membrane from a cell. Explain why:

(i) both membranes allowed lipid soluble molecules to pass through

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(1)

(ii) only the plasma membrane allowed glucose to pass through.

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(2)

(Total 9 marks)

8. Read the following passage.

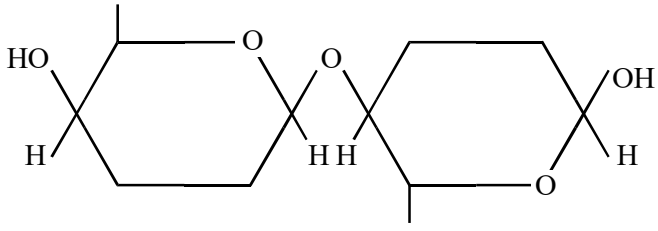
If you are lactose intolerant, drinking cow's milk will make you ill. This is the case for about half of the world's adult human population. These people lack an enzyme called lactase.

Lactase is a digestive enzyme normally found on the plasma membranes of epithelial cells in the small intestine. The enzyme hydrolyses lactose, the sugar found in milk, breaking it down to the two six-carbon sugars, galactose and β-glucose. These separate sugars are then absorbed from the intestine, a process which involves active transport.

In people who are lactose intolerant, lactose is not digested. Instead it stays in the intestine where it affects the water potential of the intestinal contents. This results in diarrhoea. Bacteria in the intestine ferment the lactose, producing carbon dioxide, methane and other gases. It is the build up of these gases which produce the other embarrassing symptoms of lactose intolerance - loud abdominal rumblings and lots of wind.

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

(a) The diagram shows a lactose molecule.



(i) Use the diagram to explain why lactose is described as a disaccharide

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(1)

(ii) On the diagram, draw a ring round the chemical bond which is hydrolysed by lactase

(1)

(iii) The molecular formula of galactose is $C_6H_{12}O_6$. What is the molecular formula of lactose

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(2)

(b) Galactose and glucose are absorbed by epithelial cells lining the small intestine but some other monosaccharides are not. Use your knowledge of active transport to explain this difference

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(2)

(c) Diarrhoea involves the production of large amounts of watery faeces. Explain the link between the presence of lactose in the intestine and diarrhoea.

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(3)

(d) The bacteria in the intestine are prokaryotic cells. The epithelial cells which line the small intestine are eukaryotic cells. Describe the ways in which prokaryotic cells and eukaryotic cells differ

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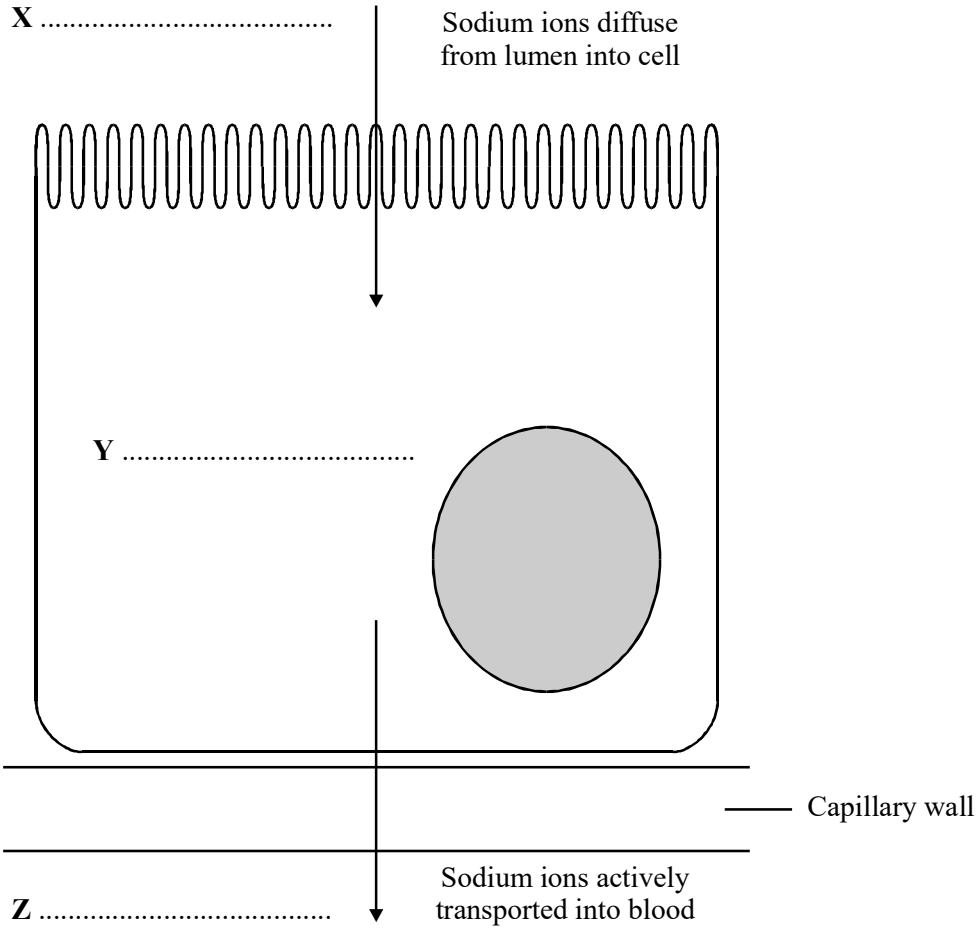
(6)

(Total 15 marks)

9. The diagram shows a cell from the small intestine of a mammal.



(a) Sodium ions diffuse into the cell from the lumen of the intestine. They move out of the cell into the blood by active transport. Complete the diagram by using the words high or low to show the relative concentration of sodium ions at **X**, **Y** and **Z**.

(1)

(b) A number of factors influence the rate of diffusion. They may be summarised by Fick's law.

$$\text{Rate of diffusion is proportional to } \frac{\text{Surface area} \times \text{Difference in concentration}}{\text{Thickness of exchange surface}}$$

Complete the table to show which factors are high and which are low when there is a rapid rate of diffusion.

Factor	Value of factor which produces a rapid rate of diffusion (high or low)
Surface area	
Difference in concentration	
Thickness of exchange surface	

(1)

(c) There is a rapid rate of diffusion of sodium ions into the cell shown in the diagram.

(i) Explain how **one** structural feature shown on the diagram helps to ensure a rapid rate of diffusion.

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(1)

(ii) Explain how active transport of sodium ions out of this cell helps to ensure a rapid rate of diffusion of sodium ions into the cell.

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(1)

(d) Describe and explain the effect of an increase in temperature on the rate of diffusion.

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(2)
(Total 6 marks)

10. Read the following passage.

Many different processes essential to life depend on proteins. These include enzyme controlled reactions, transport across plasma membranes and the binding of hormones to receptor molecules on their target cells. Every protein molecule has a tertiary structure which gives it a precise three-dimensional shape. The function of the protein depends on this shape, and the shape depends on the pH of the surrounding solution.

Changes in pH affect different proteins in different ways. This is because the amino acid molecules from which they are built have different structures. Some of these amino acids have different charges at different pH values. Unless they have the correct charges, the protein molecule will not have its correct three-dimensional shape.

If hydrogen or hydroxyl ions are added to a solution, its pH will normally change. A buffer solution is one which maintains a constant pH when hydrogen or hydroxyl ions are added to it. Buffers also occur naturally and play an important role in keeping conditions inside living organisms constant.

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

(a) The receptor molecules to which hormones bind are proteins. Glucagon is a hormone.

(i) Use the information in the first paragraph to explain why glucagon will only bind to one particular type of receptor molecule.

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(2)

(ii) Suggest why glucagon is able to bind to liver cells but not to cells in other parts of the body.

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(1)

(b) Explain how the amino acids from which proteins are built (lines 6–7) differ in structure from each other.

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(1)

(c) Amylase is an enzyme, found in saliva, which breaks down starch. It works best at a pH of 8. Explain why amylase does not function in the stomach where the pH is approximately 3.

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(3)

(d) When a suspension of mitochondria is prepared from liver, the tissue is ground in a buffer solution, then centrifuged. Explain why a buffer solution is used.

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(2)

(e) Describe how proteins are arranged in a plasma membrane and the part they play in transporting substances into and out of cells.

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(6)
(Total 15 marks)

11. (a) Describe how phospholipid molecules are arranged in a plasma membrane.

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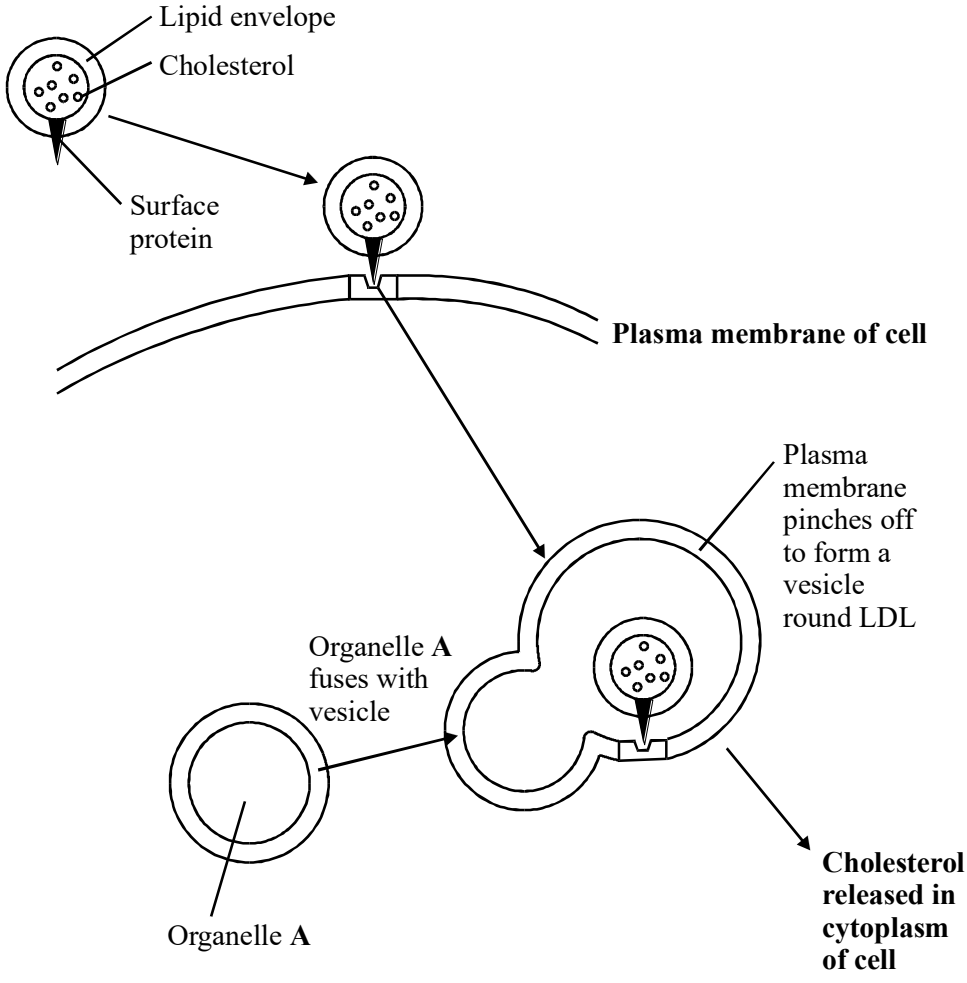
(2)

Cholesterol is a substance needed in human cells. It is carried in the blood in a particle called a low-density lipoprotein (LDL). The diagram shows how an LDL is taken into a cell and how the cholesterol it contains is released in the cytoplasm.

LDL in blood plasma



(b) Suggest why an LDL will only attach to certain areas on the plasma membrane of a cell.

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(1)

(c) Name the process by which the LDL enters the cell.

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(1)

(d) (i) Name organelle **A**.

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(1)

(ii) Explain how this organelle is involved in the release of cholesterol from the vesicle.

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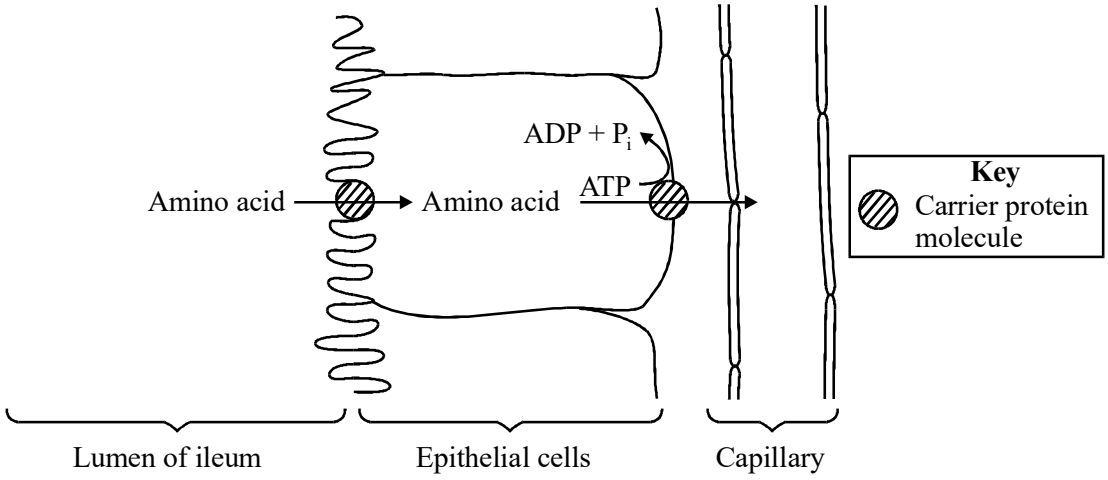
(2)

(Total 7 marks)

12. The diagram shows how amino acids are absorbed from the lumen of the ileum.



S Describe how the processes shown in the diagram enable the epithelial cells to absorb amino acids continuously.

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(Total 3 marks)

13. Read the following passage.

Human milk contains all the nutrients a young baby needs in exactly the right proportions. It is formed in the mammary glands by small groups of milk-producing cells. These cells absorb substances from the blood and use them to synthesise the lipids, carbohydrates and proteins found in milk. Milk-producing cells are roughly cube-shaped and have a height to breadth ratio of approximately 1.2 : 1.

The main carbohydrate in milk is lactose. Lactose is a disaccharide formed by the condensation of two monosaccharides, glucose and galactose. (A molecule of galactose has the same formula as a molecule of glucose – the atoms are just arranged in a different way.)

Lactose is synthesised in the Golgi apparatus and transported in vesicles through the cytoplasm. Because lactose is unable to escape from these vesicles, they increase in diameter as they move towards the plasma membrane. The vesicle membranes fuse with the plasma membrane and the vesicles empty their contents out of the cell.

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

(a) (i) The breadth of a milk-producing cell is 26 μm. Calculate the height of this cell.

Height = ... μm

(1)

(ii) Describe and explain how you would expect the height to breadth ratio of an epithelial cell from a lung alveolus to differ from the height to breadth ratio of a milk-producing cell.

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(2)

(b) How many oxygen atoms are there in a molecule of

(i) galactose;

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(1)

(ii) lactose?

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(1)

(c) The lactose-containing vesicles increase in diameter as they move towards the plasma membrane of the milk-producing cell (lines 11-12). Use your knowledge of water potential to explain why.

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(2)

(d) Suggest **one** advantage of milk-producing cells containing large numbers of mitochondria.

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(2)

(e) Some substances pass through the plasma membrane of a milk-producing cell by diffusion. Describe the structure of a plasma membrane and explain how different substances are able to pass through the membrane by diffusion.

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(6)
(Total 15 marks)

14. (a) Explain why the rate of diffusion is more rapid at higher temperatures.

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(2)

(b) Fick's law can be summarised as

$$\text{Rate of diffusion is proportional to } \frac{\text{Surface area} \times \text{Difference in concentration}}{\text{Thickness of exchange surface}}$$

Complete the table by adding the words maximum or minimum to show the values of the features in Fick's law which will ensure

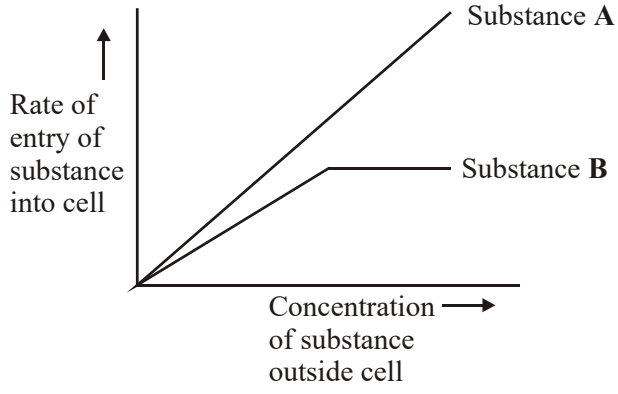
(i) efficient absorption of digested food from the small intestine;

(ii) reduction of water loss from a leaf.

Feature	Efficient absorption of digested food from the small intestine	Reduction of water loss from a leaf
Surface area		
Difference in concentration		
Thickness of exchange surface		

(2)

(c) The graph shows how the concentration of a substance affects its rate of absorption into a cell.



(i) Substance **A** enters the cell by simple diffusion. Use Fick's law to explain the shape of the curve.

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(1)

(ii) Substance **B** enters the cell by facilitated diffusion. Explain the evidence from the graph which supports this.

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(2)
(Total 7 marks)

15. In the lungs, the alveoli are the site of gas exchange.

(a) A large number of small alveoli is more efficient in gas exchange than a smaller number of larger alveoli. Explain why.

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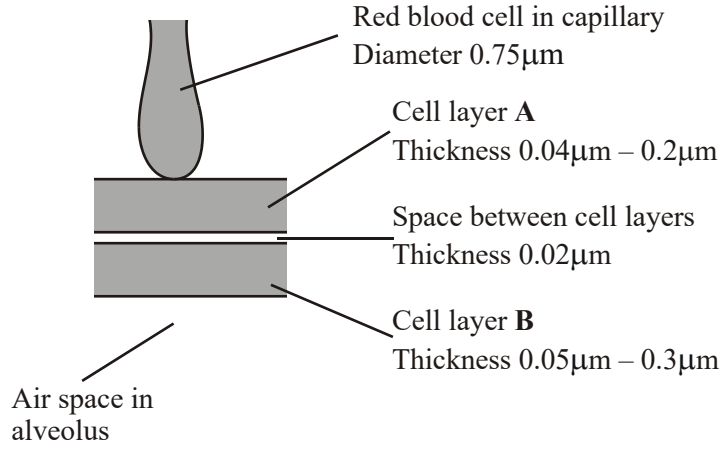
(2)

(b) The diagram shows part of an alveolus and a capillary.



(i) Name the type of cells in layer **B**.

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(1)

(ii) What is the minimum distance a molecule of carbon dioxide diffuses from the blood plasma to the air space in the alveolus?

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(1)

(c) Just before a person starts to exhale, the composition of the air in an alveolus differs from the composition of the air in the trachea.

(i) Give **two** ways in which the composition would differ.

1 .....

2 .....

(1)

(ii) Explain what causes this difference in composition between the air in the alveolus and the air in the trachea.

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(1)

(d) The partial pressure of a gas is a measure of the amount of gas that is present.
The partial pressure of carbon dioxide in blood going to the lungs is 6.3 kPa.
The partial pressure of carbon dioxide in an alveolus is 5.3 kPa.

(i) Through which vessel does blood leave the heart to go to the lungs?

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(1)

(ii) Suggest why blood returning to the heart from the lungs contains some carbon dioxide.

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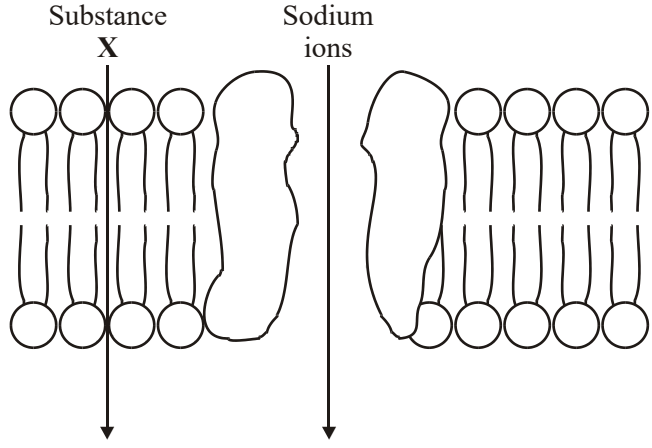
(2)
(Total 9 marks)

16. The diagram shows part of a plasma membrane. The arrows show the path taken by sodium ions and by substance **X** when they diffuse through the membrane into a cell.



(a) An optical microscope cannot be used to see a plasma membrane. Explain why.

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(2)

(b) Give **one** property of the molecules of substance **X** which allows them to diffuse through the membrane at the position shown.

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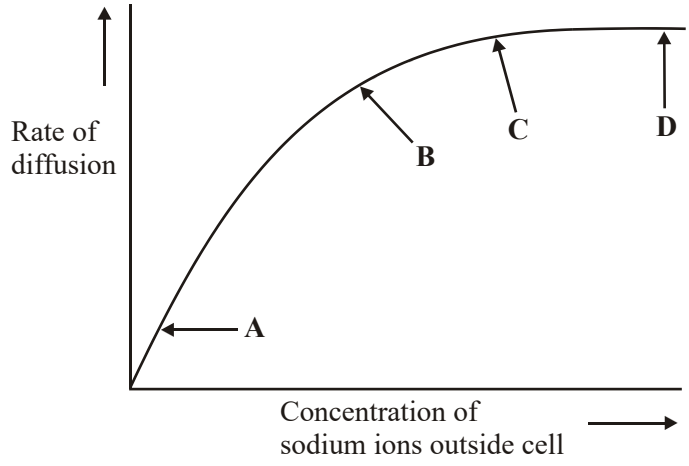
(1)

(c) The effect of the concentration of sodium ions in the surrounding solution on their rate of diffusion across the membrane was investigated. The graph shows the results.



(i) What limits the diffusion of sodium ions across the membrane between **A** and **B** on the graph? Give the evidence for your answer.

Limiting factor .....

Evidence .....

.....

(2)

(ii) Explain the shape of the curve between **C** and **D**.

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(2)
(Total 7 marks)

17. Read the following passage.

The plasma membrane plays a vital role in microorganisms. It forms a barrier between the cell and its environment, controlling the entry and exit of solutes. This makes bacteria vulnerable to a range of antiseptics and antibiotics

When bacteria are treated with antiseptics, the antiseptics bind to the proteins in the membrane and create tiny holes. Bacteria contain potassium ions at a concentration many times that outside the cell. Because of the small size of these ions and their concentration in the cell, the first observable sign of antiseptic damage to the plasma membrane is the leaking of potassium ions from the cell. Some antibiotics damage the plasma membrane in a similar way. One of these is tyrocidin. This is a cyclic polypeptide consisting of a ring of ten amino acids. Tyrocidin and other polypeptide antibiotics are of little use in medicine.

Other antibiotics also increase the rate of potassium movement from cells. It is thought that potassium ions are very important in energy release and protein synthesis, and a loss of potassium ions would lead to cell death. Gramicidin A coils to form a permanent pore passing through the plasma membrane. This pore enables potassium ions to be conducted from the inside of the cell into the surrounding medium. Vanilomycin also facilitates the passage of potassium ions from the cell. A molecule of vanilomycin forms a complex with a potassium ion and transports it across the membrane. The potassium ion is released on the outside and the vanilomycin is free to return and pick up another potassium ion. Vanilomycin depends on the fluid nature of the plasma membrane in order to function.

Polyene antibiotics have flattened, ring-shaped molecules. The two sides of the ring differ from each other. One side consists of an unsaturated carbon chain. This part is strongly hydrophobic and rigid. The opposite side is a flexible, strongly hydrophilic region. It has been shown that polyene antibiotics bind only to sterols. Sterols are lipids found in the membranes of eukaryotes but not in the membranes of prokaryotic organisms. It is thought that several sterol-polyene complexes come together. The plasma membranes of eukaryotic cells treated with these polyene antibiotics lose the ability to act as selective barriers and small ions and molecules rapidly leak out

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

(a) (i) By what process do potassium ions normally enter a bacterial cell? Explain the evidence for your answer.

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(2)

(ii) Use Fick's law to explain why leakage of potassium ions occurs following antiseptic damage to the plasma membrane (lines 7 - 8).

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(2)

(b) (i) Draw a peptide bond showing how the COOH group of one amino acid joins to the NH_2 group of another.

(1)

(ii) How many peptide bonds are there in a molecule of tyrocidin (lines 9 - 10)?

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(1)

(c) Experiments have shown that vanilomycin is unable to transport potassium ions across a membrane when it is cooled. Gramicidin A continues to facilitate the movement of potassium ions at these low temperatures. Explain these results.

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(3)

(d) Draw a simple diagram of one of the phospholipid layers to show how polyene antibiotics allow small ions and molecules to leak rapidly through a plasma membrane.
Use the following symbols to represent the different molecules.

Note that the zigzag line on the symbol for the polyene antibiotic represents its hydrophobic region.

Phospholipid

Sterol

Polyene antibiotic

These symbols have been drawn to the same scale

(2)
(Total 11 marks)

18. (a) Discs of carrot were placed in a solution containing potassium ions (K^+). The concentration of oxygen in air bubbled through the solution was changed and the rates of respiration and uptake of potassium ions were measured. The results are shown in the table.

Concentration of oxygen / %	**Rate of respiration / arbitrary units**	**Rate of uptake of potassium ions / arbitrary units**
2.7	31	29
12.2	69	72
20.8	90	80

Describe and explain the link between oxygen concentration, rate of respiration and rate of uptake of potassium ions.

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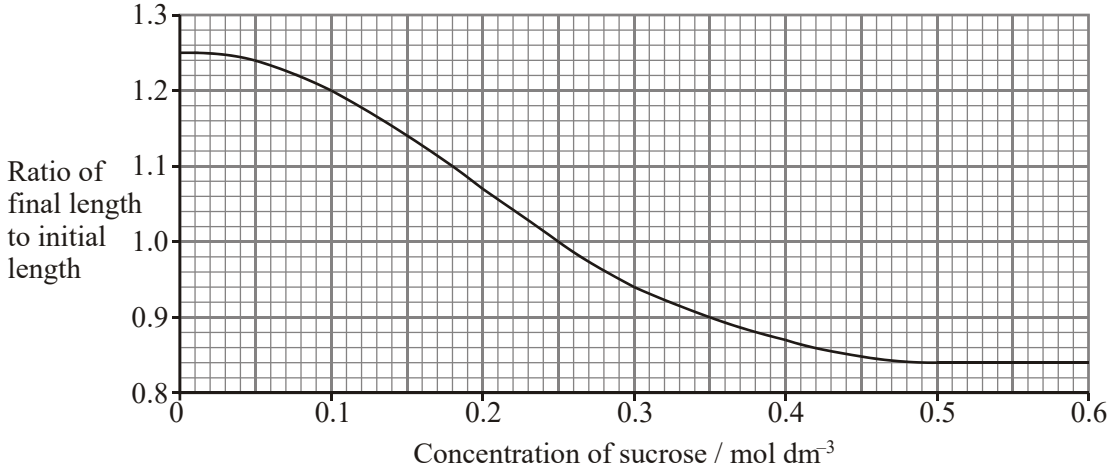
(4)

(b) Cylinders of potato were cut using a cork borer. Their initial lengths were measured. Each cylinder was then put in a different concentration of sucrose solution for 12 hours. The graph shows the changes in length of the potato cylinders in the different sugar solutions.



(i) In what concentration of sucrose did the length of the potato cylinder remain the same?

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(1)

(ii) The initial length of the potato cylinder in the solution of concentration 0.1 mol dm^{-3} was 90 mm. Calculate its final length. Show your working.

Final length = ... mm

(2)

(iii) Explain the change in length which occurs in a sucrose solution of concentration 0.5 mol dm^{-3}.

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(2)

(Total 9 marks)

19. (a) A plant cell was observed with an optical microscope. Describe how the length of the cell could be estimated.

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(2)

(b) The water potential of a plant cell is –400 kPa. The cell is put in a solution with a water potential of –650 kPa. Describe and explain what will happen to the cell.

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(3)

(c) A group of students investigated the effect of sucrose concentration on the change in length of cylinders of tissue cut from a young carrot. They measured the initial lengths of the carrot cylinders, then placed one in each of a number of sucrose solutions. After 18 hours, they removed the carrot cylinders and measured their final lengths. Some of the results are shown in the table.

Concentration of sucrose / mol dm^{-3}	**Percentage decrease in length of carrot cylinder**
0.4	4.2
0.5	8.7
0.6	13.0
0.7	16.8
0.8	18.1
0.9	18.1
1.0	18.1

(i) The carrot cylinders were left for 18 hours in the sucrose solutions. Explain why they were left for a long time.

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(1)

(ii) Explain how you would use a graph to predict the concentration of sucrose that would result in no change in length of the carrot cylinders.

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(2)

(iii) Young carrots store sugars in their tissues but, in older carrots, some of this is converted to starch. How would using cylinders of tissue from older carrots affect the results obtained for a sucrose solution of 0.6 mol dm^{-3}? Give a reason for your answer.

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(2)
(Total 10 marks)

20. Trandescantia is a house plant. There are small hairs on its flowers. These hairs are made of cells. **Figure 1** shows the appearance of cells from one of these hairs after 20 minutes in distilled water. **Figure 2** shows cells from another hair after 20 minutes in a solution of potassium nitrate.

Figure 1 (in distilled water)

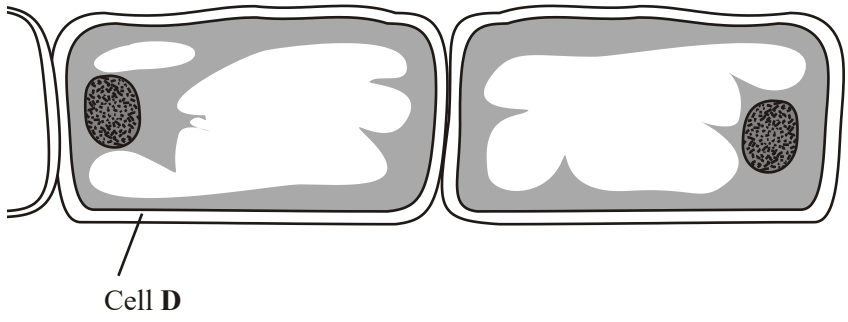
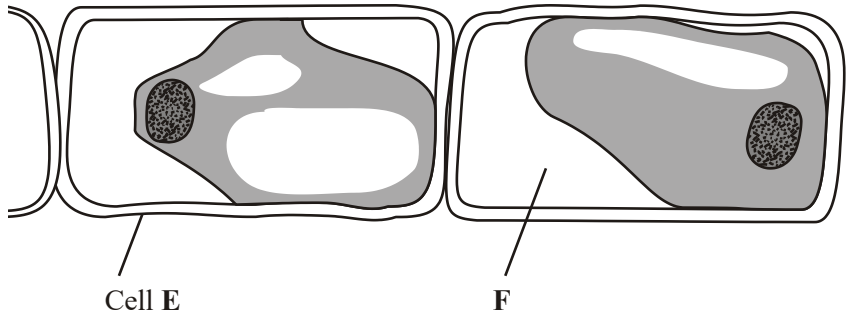


Figure 2 (in potassium nitrate solution)



(a) What does **Figure 2** suggest about the permeability of the plasma membranes surrounding these cells?

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(1)

(b) What is present in the space labelled **F**? Explain your answer.

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(2)

(c) How would the water potential of the sap in the vacuole of cell **E** differ from the water potential of the sap in the vacuole of cell **D**? Explain your answer.

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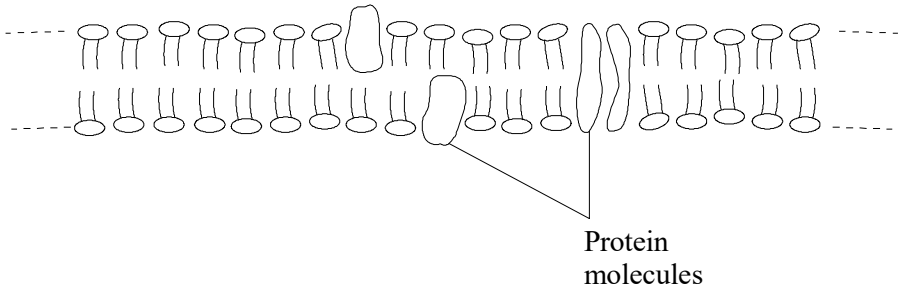
(3)

(Total 6 marks)

21. The diagram shows the fluid mosaic model of cell membrane structure.



(a) Suggest why this model is known as *fluid mosaic*.

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(2)

(b) Give **two** functions of the protein molecules in the cell membrane.

1. .....

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2. .....

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(2)

(c) Explain how hydrophobic areas in the membrane are important to its function.

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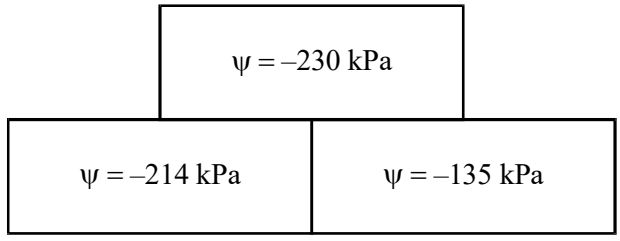
(2)

(d) (i) The diagram shows the water potentials (Ψ) of three cells in contact with one another.

Use arrows to show the net direction of water movement between **all three** cells.



(1)

(ii) If solute were added to a cell what effect would this have on the water potential within that cell ?

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(1)
(Total 8 marks)

22. (a) (i) Give **two** ways in which active transport differs from diffusion.

1.....

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2.....

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(2)

(ii) Sodium ions move from the surrounding solution where they are at a low concentration into the cytoplasm of a cell where they are at a higher concentration. Cyanide ions stop the functioning of the electron carrier system in mitochondria.

Use these two pieces of information to explain how the addition of cyanide ions would affect the uptake of sodium ions by a cell.

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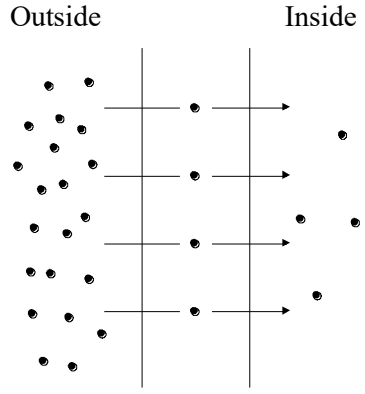
(2)

(b) Two major routes by which molecules are thought to cross membranes are:

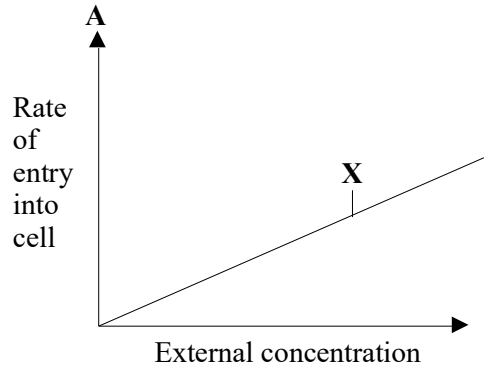
1. by dissolving in the phospholipid layer.

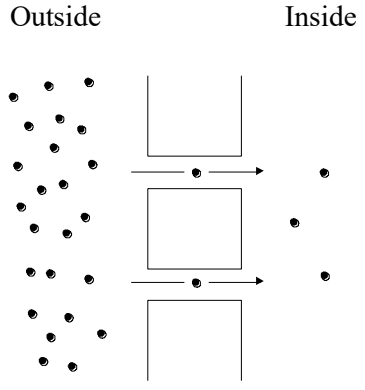
2. by passing through channels in protein molecules.

These routes are illustrated in the diagram. The graphs show the rate of entry of molecules into the cell by these two routes in relation to the external concentration of the molecules.

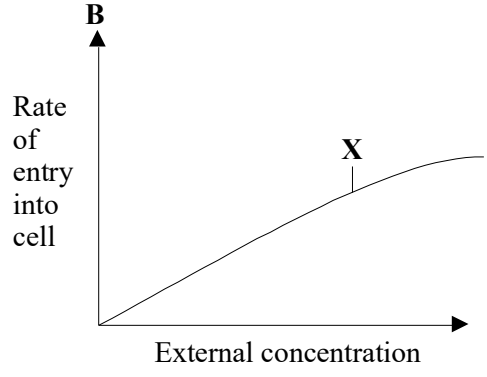


Molecules dissolve in phospholipid layer





Molecules pass through protein channels



(i) Explain why curves are similar up to point **X**

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(1)

(ii) Explain what causes the shapes of the curves to differ after point **X.**

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(1)
(Total 6 marks)

23. The roots of two groups of pea plants were placed in solutions containing radioactive potassium ions. For the experimental plants a respiratory inhibitor was added to the solution. The control plants had no respiratory inhibitor added. At regular intervals the solutions surrounding the roots were tested for radioactive potassium ions.
The table shows the results of this investigation.

Time from placing roots in solution / minutes	Concentration of radioactive potassium ions in the solutions surrounding the roots / arbitrary units	
	Experimental plants	Control plants
0	7.5	7.5
15	6.6	3.3
30	6.4	2.9
60	6.3	2.4
120	6.3	1.2
240	6.3	0.6

(i) The rate of uptake of potassium ions by the experimental plants in the first 15 minutes was 0.06 units per minute.
Calculate the rate of uptake of potassium ions by the control plants over the same time period.

Rate of uptake by control plants = ...

(1)

(ii) Suggest an explanation for the difference between the rates of uptake by the experimental and control plants in the first 15 minutes.

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(2)

(iii) The rate of potassium ion uptake by the control plants in the first hour was faster than in the second hour. Suggest why.

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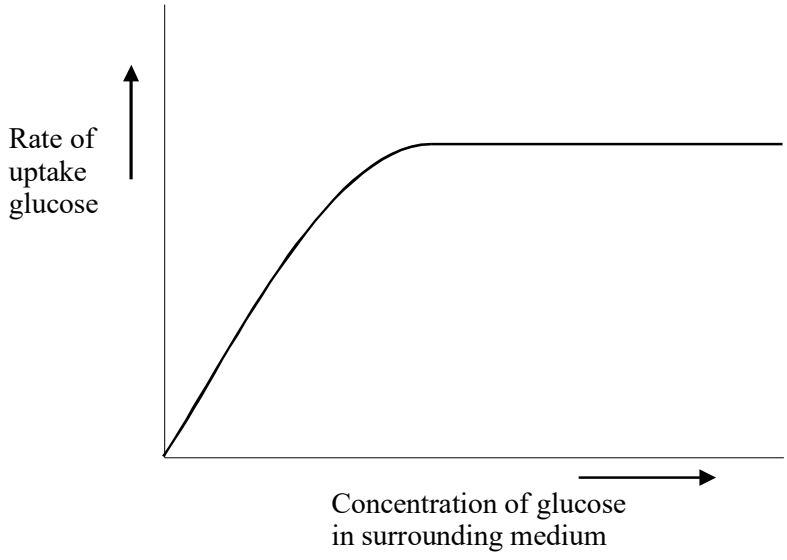
(2)
(Total 5 marks)

24. Protein molecules in the cell surface membrane are involved in the active transport of glucose molecules into the cell.

(a) The graph shows how the uptake of glucose by red blood cells varies with the glucose concentration of the surrounding medium.



Explain the shape of the curve.

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(3)

(b) The table shows the results of an investigation into differences in the rates of uptake of different sugars by red blood cells.

Sugar	Relative rate of uptake
Glucose	100
Galactose	13
Xylose	7

(i) Give **one** factor, other than the concentration of sugar in the surrounding medium, which should have been standardised in this investigation. Describe and explain how variation in this factor would affect the rate of uptake.

Factor.....

Explanation.....

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(2)

(ii) Use your knowledge of protein molecules in cell surface membranes to suggest why the rate of uptake of these sugars differs.

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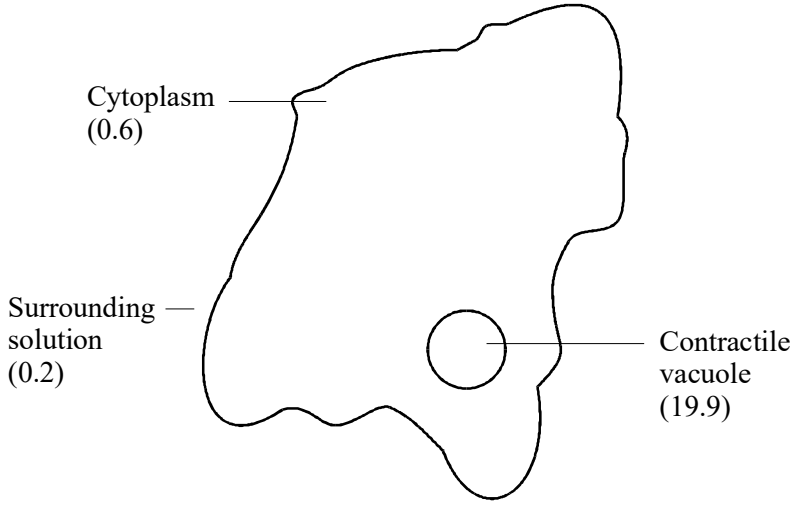
(2)
(Total 7 marks)

25. The diagram shows a species of amoeba, a single-celled organism, which lives in freshwater. The figures show the concentration of sodium ions in mol dm^{-3} inside the organism and in the surrounding solution.



(a) (i) There are large numbers of mitochondria in the cytoplasm close to the contractile vacuole. What does this suggest about the way in which sodium ions enter the contractile vacuole? Explain your answer.

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(2)

(ii) Water moves into the cytoplasm from the surrounding solution. This water moves from the cytoplasm into the contractile vacuole and is then expelled from the organism. Explain how water moves from the cytoplasm into the contractile vacuole.

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(3)

(b) Some species of amoeba live in the sea. Suggest why contractile vacuoles are not found in these species.

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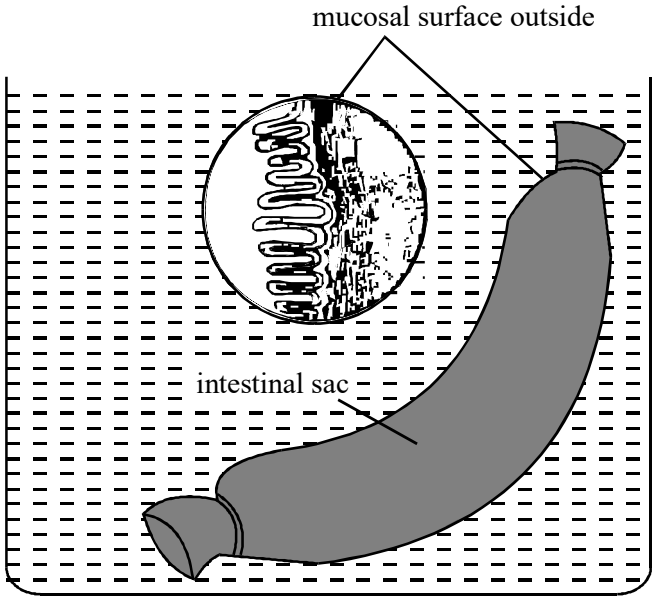
(2)

(Total 7 marks)

26. The diagram shows how an experiment was set up to investigate absorption by active transport and diffusion in the small intestine. A piece of small intestine was turned inside out, so that the surface with the villi was on the outside. The ends of the intestine were tied to form a sac. The sac was placed in an oxygenated, buffered solution at 37°C. Substances which were transported through the villi in the normal direction became concentrated within the sac.



(a) Suggest why, in order to investigate active transport, the solution in which the sac was placed was

(i) oxygenated;

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.....

(ii) buffered.

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(3)

(b) Using this technique, the following data were obtained about the absorption of sugars from small intestine which had been treated with a respiratory inhibitor and from untreated small intestine.

Sugar	Relative rates of absorption from small intestine	
	treated with respiratory inhibitor	untreated
Glucose	30	100
Fructose	31	30

Explain what the table suggests about the ways in which glucose and fructose are absorbed from the small intestine.

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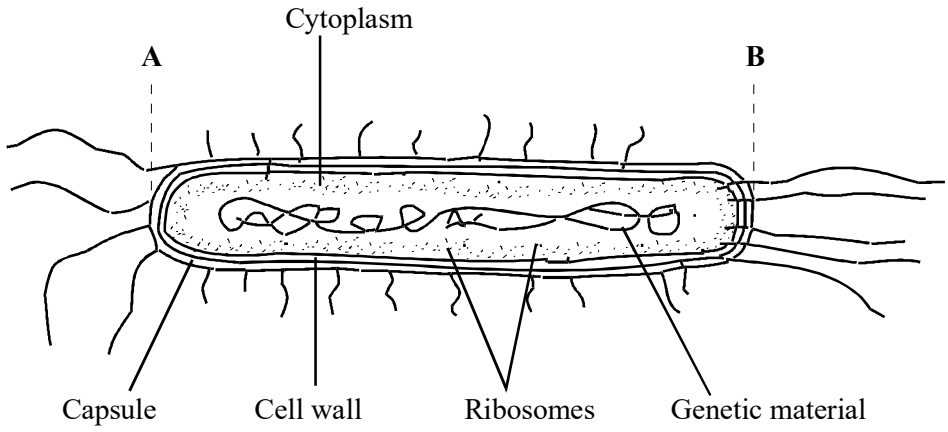
(4)

(Total 7 marks)

27. The diagram shows an *Escherichia coli* bacterium at a magnification of x 20 000.



(a) What is the actual length of the bacterium from A to B in micrometres (μm)?

Show your working.

Length.....micrometres

(2)

(b) For each of the following, give **one** way in which the structure or location in *E. Coli* differs from that in a eukaryotic cell.

(i) genetic material

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(1)

(ii) ribosomes

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(1)

(iii) respiratory enzymes

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(1)

(c) *E.coli* bacteria can regulate their water content by active transport of potassium ions. A decrease in the water potential of the solution around the bacteria stimulates active uptake of potassium ions.

Explain how this would help the bacteria to regulate their water content.

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(2)
(Total 7 marks)

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

1 .....

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2 .....

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(2)

(b) Describe how ions are transported through a cell surface membrane by active transport.

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(2)

(c) The table shows the concentration of three ions inside and outside a cell of an alga that lives in pond water.

Ion	Concentration of ion in cytoplasm / mmol dm^{-3}	Concentration of ion in pond water / mmol dm^{-3}
Chloride	58.0	1.3
Potassium	93.0	0.1
Sodium	51.0	1.0

(i) By how many times have the potassium ions been concentrated in the cytoplasm compared with the pond water?

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(1)

(ii) The ions enter the cell of the alga by active transport. What does the information in the table suggest about the active transport of these three ions through the cell surface membrane? Explain your answer.

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(2)

(Total 7 marks)

29. Peeled potatoes were cut into two sizes of cubes - $1cm^3$ (1cm x 1cm x 1cm) and $27cm^3$ (3cm x 3cm x 3cm). After weighing, twenty-seven of the $1cm^3$ cubes were placed in one beaker of distilled water, and one $27cm^3$ cube was placed in another beaker. One hour later the cubes were removed and their surfaces carefully dried. They were then reweighed. The results are shown in the table.

	Small cubes	**Large cube**
Volume of cube / cm^3	1	27
Surface area of cube / cm^2	6	54
Number of cubes in beaker	27	1
Surface area : volume ratio of one cube		
Total mass of cubes at start / g	52.75	52.97
Total mass after 1 hour in water / g	55.31	53.55
Increase in mass / g	2.56	0.58
Percentage increase in mass		

(a) Complete the table to show

(i) the surface area : volume ratio for each size of cube;

(ii) the percentage increase in mass after 1 hour in water.

(2)

(b) (i) Why did the experimenter use twenty-seven small cubes?

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(1)

(ii) Explain, in terms of water potential, why the potato cubes increased in mass when placed in the distilled water.

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(2)

(iii) The percentage increase in mass of the smaller cubes was greater than the percentage increase in mass of the large cube. Explain the difference.

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(1)
(Total 6 marks)

30. (a) Describe the fluid-mosaic structure of a cell surface membrane.

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(5)

(b) Explain each of the following processes by which substances pass through a cell surface membrane.

(i) diffusion of oxygen

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(ii) facilitated diffusion of glucose

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(iii) active transport of sodium ions

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(9)
(Total 14 marks)

31. Wheat plants were grown for several days with their roots in a nutrient solution. At the end of the investigation the concentration of the different ions was measured in both the root cell cytoplasm and the external nutrient solution. The results are shown in the table.

Ion	Concentration of ion in external nutrient solution/μmol dm^{-3}	Concentration of ion in root cell cytoplasm/ μmol dm^{-3}
Potassium	30	90
Sodium	30	5
Nitrate	10	62

(a) (i) By how many times have the nitrate ions been concentrated in the root cell cytoplasm compared with the nutrient solution?

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(1)

(ii) Name the process that results in the concentration of nitrate ions becoming greater in the cytoplasm than in the nutrient solution.

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(1)

(b) Some ions can enter the cell faster than others. Use your knowledge of membrane structure to suggest an explanation for this.

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(2)

(c) Explain why it was necessary to bubble air through the nutrient solution during this investigation.

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(1)
(Total 5 marks)

32. (a) Give two ways in which osmosis differs from facilitated diffusion.

1 .....

2 .....

(2)

(b) Jam contains a high concentration of sugar. Explain why bacteria that cause decay do not grow in jam.

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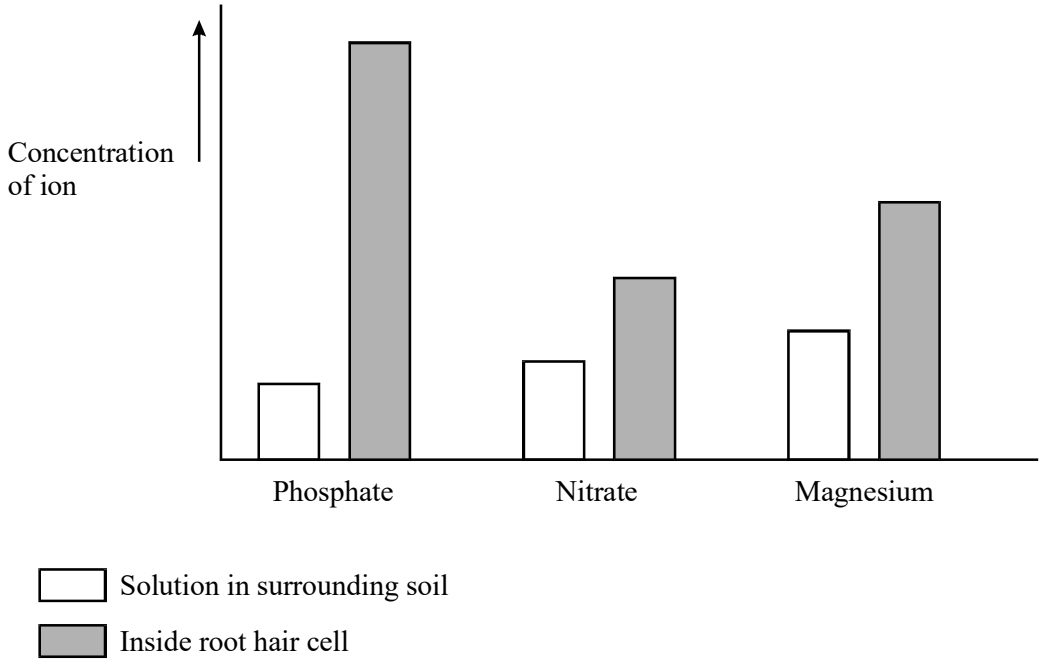
(3)
(Total 5 marks)

33. (a) Complete the table, with a tick for a true statement or a cross for a false statement, to show the functions of phospholipids and proteins in a cell membrane.

Function	Phospholipids	Proteins
May act as hormone receptors		
May act as enzymes		
Involved in active transport		

(2)

(b) Root hair cells take up ions from the solution in the surrounding soil. The graph shows the concentrations of various ions inside root hair cells and in the solution in the surrounding soil.



Name the process which the cell is using to absorb these ions. Use information in the graph to justify your answer.

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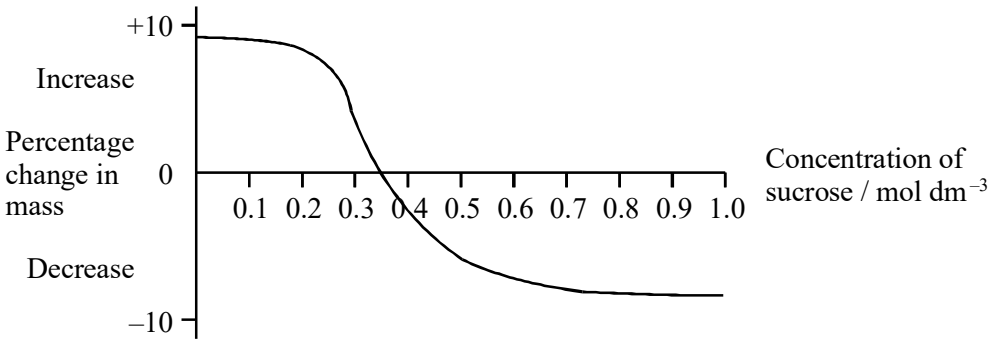
(2)

(Total 4 marks)

34. (a) Cylinders of potato were cut using a cork borer. Each cylinder was placed into one of a range of sucrose solutions of different concentrations. The cylinders were left for 6 hours and then removed from the solutions. The mass of each cylinder was recorded before and after immersion. The graph shows the results of this investigation.



(i) Explain why the change in mass was given as a percentage change.

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(2)

(ii) Explain the shape of the curve as the concentration of sucrose decreases from 0.3 mol dm^{-3} to 0.1 mol dm^{-3}.

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(4)

(iii) What concentration of sucrose solution is equivalent to the mean water potential of the potato cells? Explain your answer.

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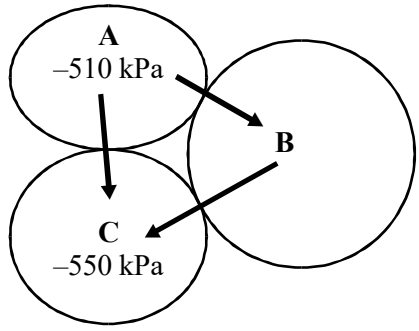
(2)

(b) The diagram represents three plant cells and shows the water potential of two of these cells. The arrows show the direction of water movement between these three cells.



Suggest the range of possible values for the water potential of cell **B**. Explain your answer fully.

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(2)

(Total 10 marks)

35. (a) Give **three** factors that would result in a high rate of diffusion of molecules of a gas such as carbon dioxide through a membrane.

1 .....

2 .....

3 .....

(3)

(b) Scientists investigated the rate of diffusion of carbon dioxide through holes of different diameter in an artificial membrane. The table shows some of their results.

Diameter of hole / mm	**Volume of carbon dioxide diffusing per hour/cm^3**	**Volume of carbon dioxide diffusing per cm^2 of hole per hour/ cm^3**
22.70	0.24	0.06
12.06	0.10	0.09
6.03	0.06	0.22
3.23	0.04	0.48
2.00	0.02	0.76

Give **two** conclusions that may be drawn from these data.

1 .....

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2 .....

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(2)
(Total 5 marks)

36. (a) Describe osmosis in terms of water potential.

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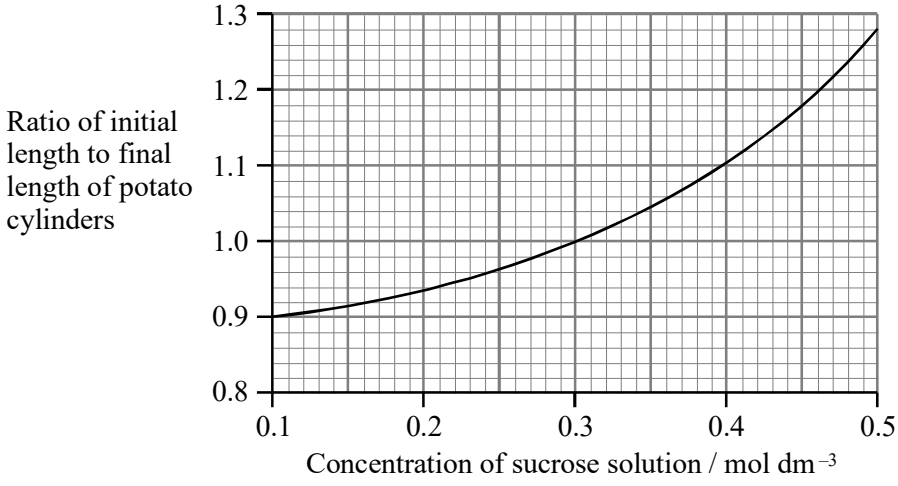
(3)

(b) In an experiment, cylinders cut from a potato were placed in sucrose solutions of different concentrations. The cylinders were measured before and after immersion in sucrose solution.

The graph shows the effect of the sucrose solutions on the length of the potato cylinders.



(i) The initial length of the potato cylinder in 0.1 mol dm^{-3} sucrose solution was 5.0 cm.
Calculate the final length of this cylinder. Show your working.

Final length ..... cm

(2)

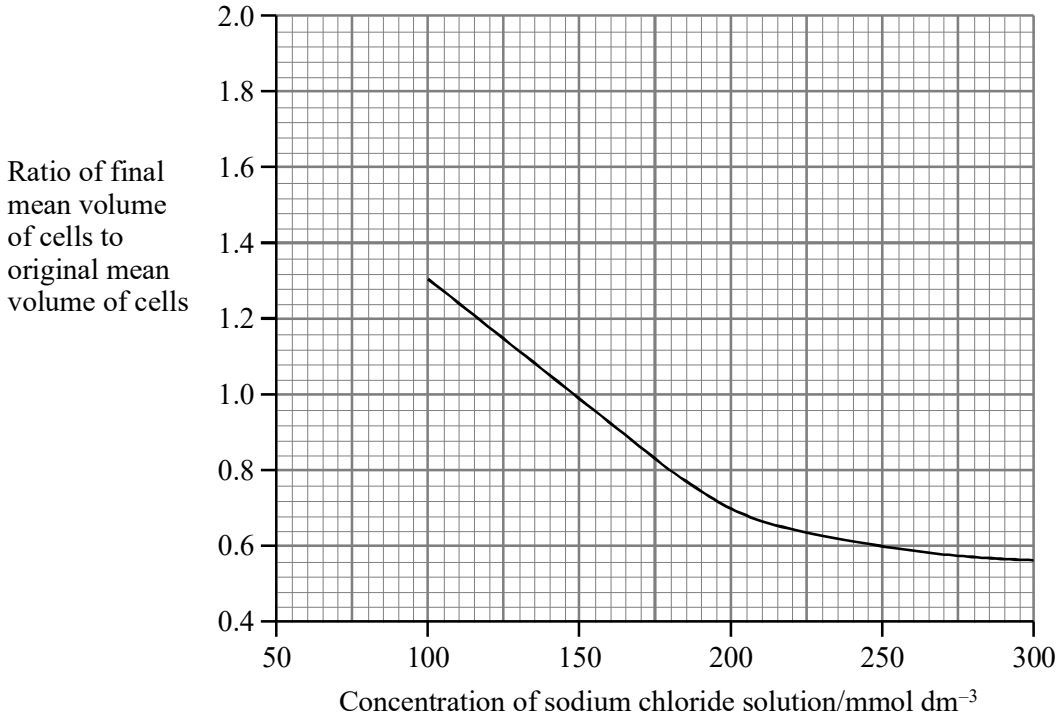
(ii) On the graph

1 mark with a **T** a point on the curve where the potato cells are turgid;

2 mark with a **W** a point on the curve where the potato cells have the same water potential as the sucrose solution.

(2)
(Total 7 marks)

37. Red blood cells were left for the same length of time in sodium chloride solutions of different concentrations. The final mean volume of the red cells was then compared with the original mean volume. The results are shown in the graph.



(a) Use the terms isotonic, hypotonic or hypertonic to explain the results for red cells placed in a sodium chloride solution of concentration

(i) 100 mmol dm^{-3};

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(ii) 150 mmol dm^{-3}.

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(4)

(b) No intact cells could be seen in the 50 mmol dm^{-3} sodium chloride solution at the end of the experiment. Only fragments of membranes could be found.
Explain why.

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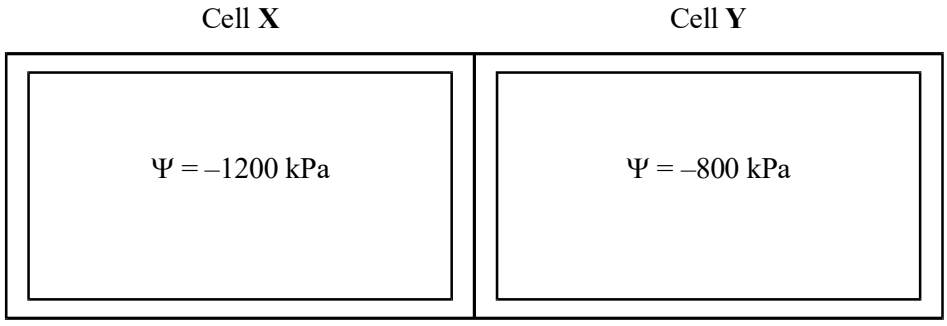
(1)

(Total 5 marks)

38. The diagram shows two adjacent plant cells (**X** and **Y**).



(a) In which direction would a net flow of water occur? Explain your answer.

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(1)

(b) *Plantago maritima* is a plant that grows in salt marshes around the coast of Britain. It is able to survive in its natural habitat without wilting by maintaining a higher concentration of solutes in its cells than in the surrounding water.

S (i) Suggest how *P. maritima* increases the concentration of solutes in its cells.

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(1)

(ii) Describe how changing the concentration of solutes will affect the water potential.

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(1)

(iii) Explain why many species of plant are unable to survive in this habitat.

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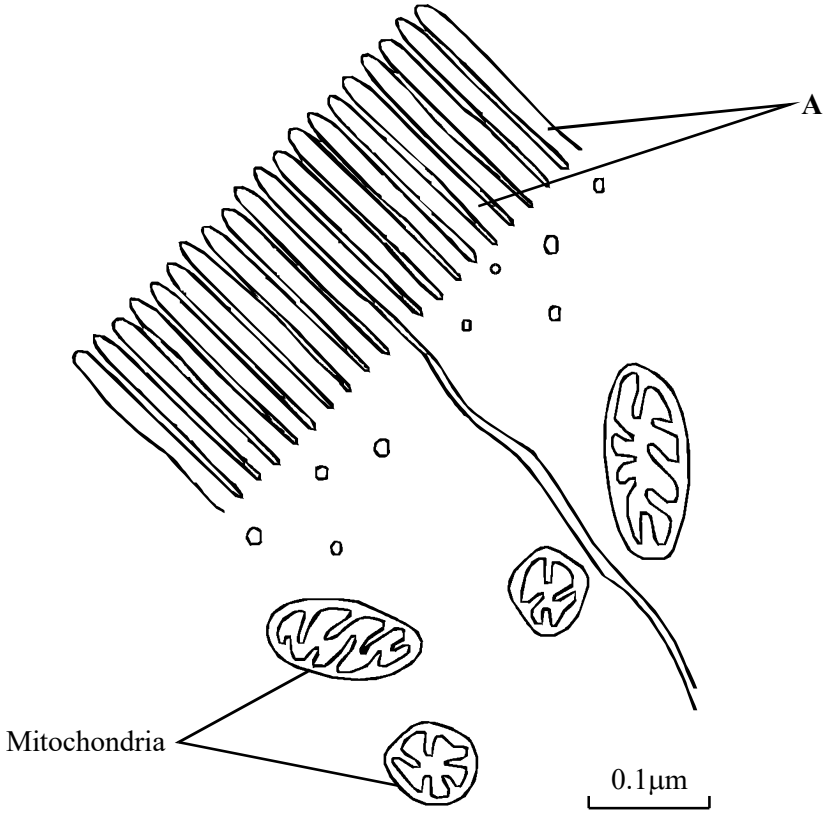
(4)
(Total 7 marks)

39. The drawing shows an electron micrograph of parts of epithelial cells from the small intestine.



(a) (i) Name the structures labelled **A**.

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(1)

(ii) Explain how these structures help in the absorption of substances from the small intestine.

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(1)

(b) (i) The scale bar on this drawing represents a length of 0.1 μm. Calculate the magnification of the drawing. Show your working.

Magnification .....

(2)

(ii) Explain why an electron microscope shows more detail of cell structure than a light microscope.

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(2)

(c) The length of mitochondria can vary from 1.5 μm to 10 μm but their width never exceeds 1μm. Explain the advantage of the width of mitochondria being no more than 1μm.

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(1)

(Total 7 marks)

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

1 .....

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2 .....

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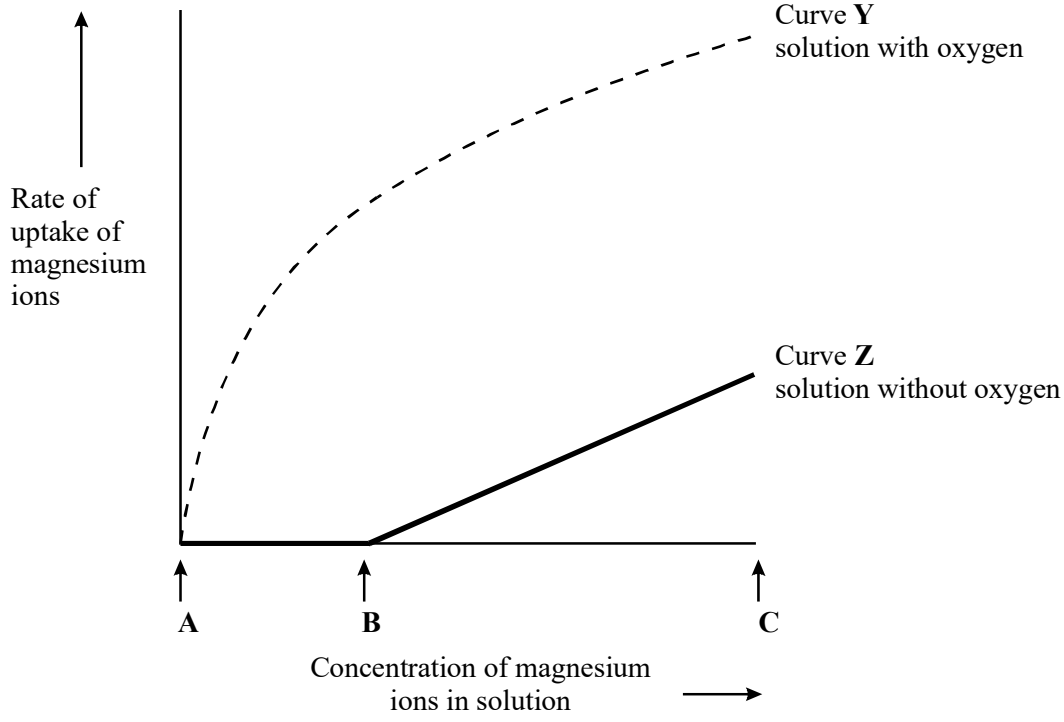
(2)

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 .....

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(2)

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

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(1)

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

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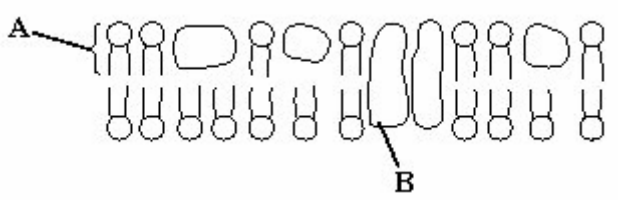
(1)

(Total 6 marks)

41. (a) The diagram shows the fluid-mosaic model of a cell surface membrane.



(i) Name the molecules labelled **A** and **B**.

A .....

B .....

(1)

(ii) How does the bilayer formed by substance **A** affect entry and exit of substances into and out of a cell?

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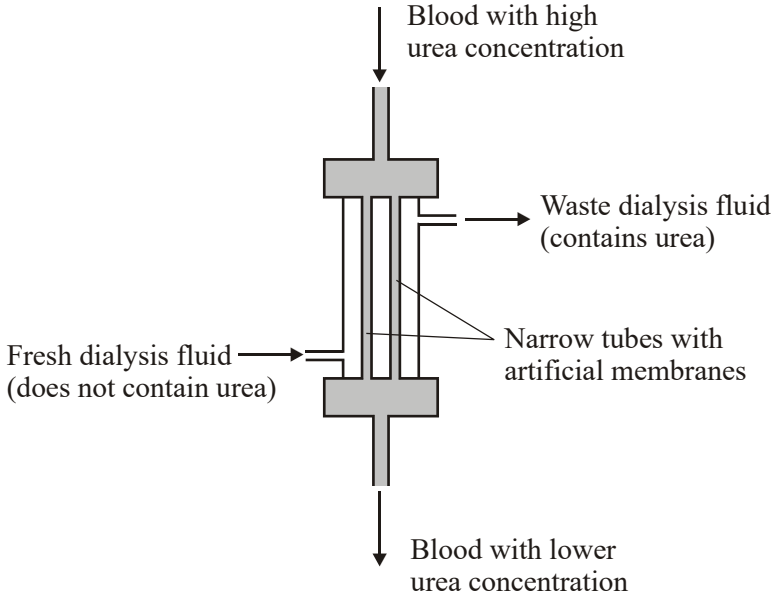
(2)

(b) A dialysis machine contains artificial membranes which enable urea to be removed from the blood of a person with kidney failure. The diagram shows a dialysis machine.



(i) By what process does urea pass from the blood into the dialysis fluid?

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(1)

(ii) Suggest **two** reasons for keeping the fluid in the dialysis machine at 40 °C rather than room temperature.

1 .....……

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2 .....……

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(2)

(iii) The blood and the dialysis fluid flow in opposite directions in the dialysis machine. Explain the advantage of this.

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(2)

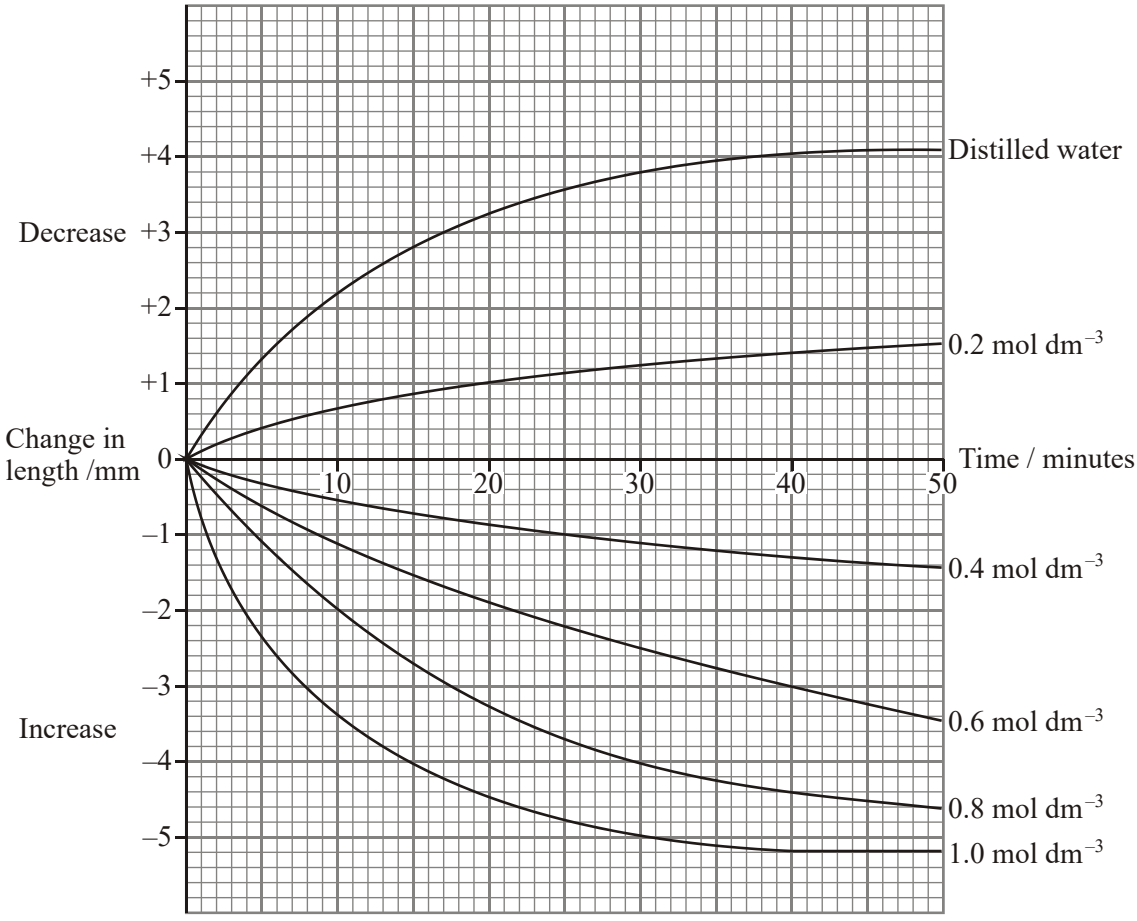
(iv) Blood flows through the dialysis machine at a rate of 200 cm^3 per minute.
Calculate the total volume which passes through the machine in 5 hours.
Give your answer in dm^3 and show your working.

Answer ..... dm^3

(2)

(Total 10 marks)

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



(a) Explain why

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

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(2)

(ii) the potato cylinder in the 1.0 mol dm^{-3} sucrose solution showed no further decrease in length after 40 minutes.

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(2)

(b) (i) Describe the difference in the rate of decrease in length during the first 10 minutes between the cylinder in the 0.4 mol dm^{-3} and the cylinder in the 0.8 mol dm^{-3} solution.

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(1)

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

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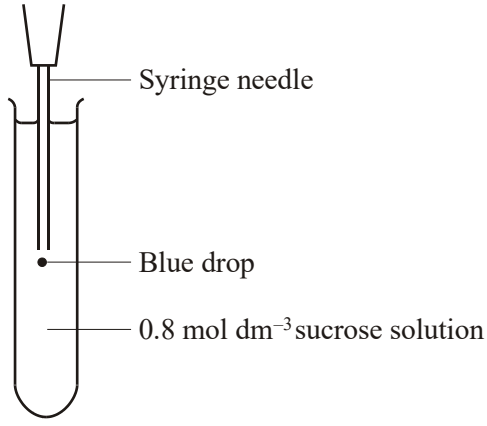
(1)

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

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(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.

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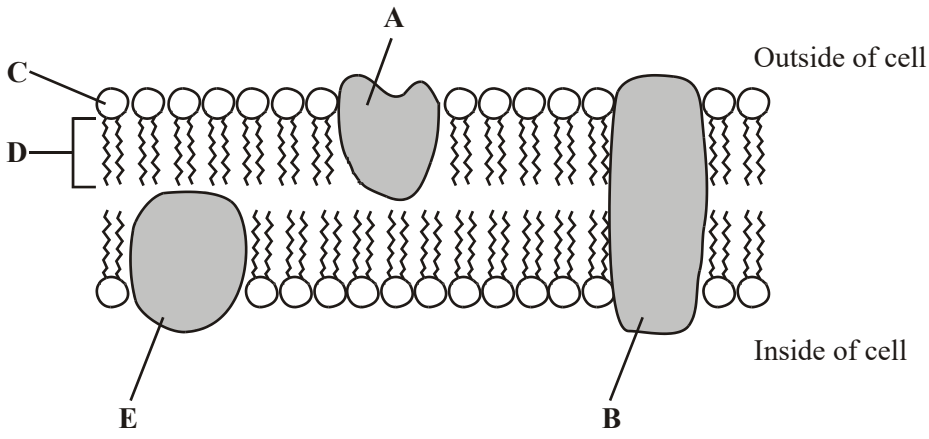
(2)

(Total 10 marks)

43. The diagram shows part of a cell surface membrane.



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

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

(2)

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

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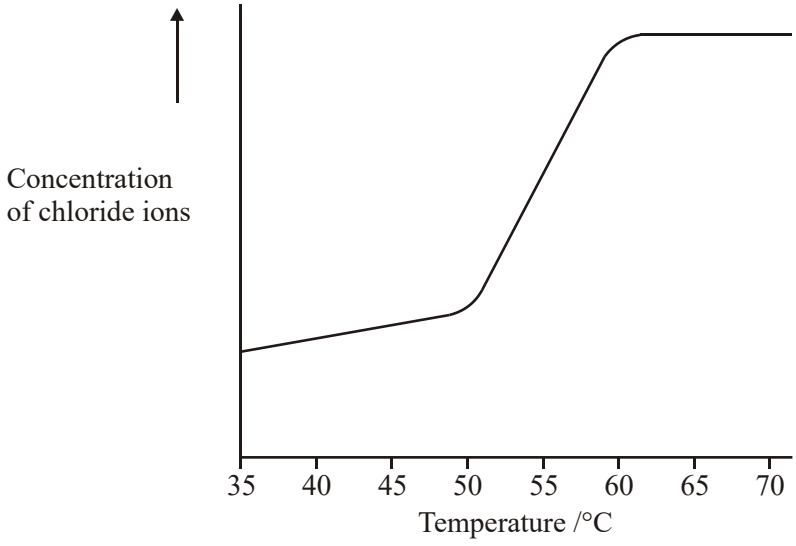
(2)

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



Describe and explain the shape of the curve.

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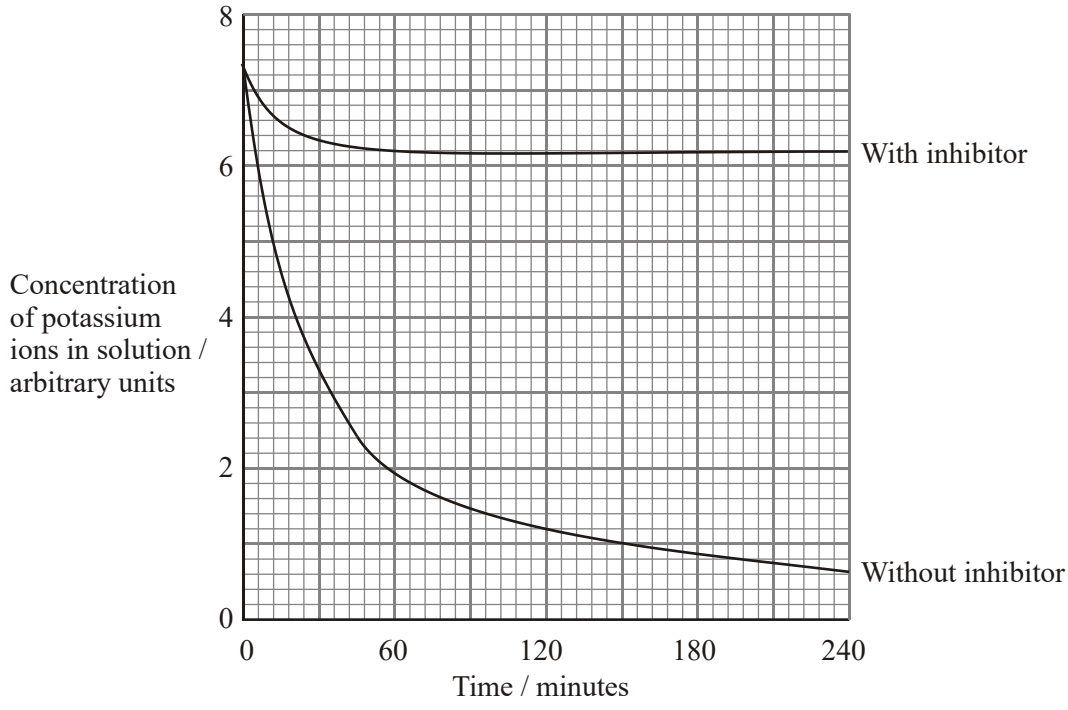
(3)
(Total 7 marks)

44. Two samples of the roots of pea plants were placed in solutions containing potassium ions. An inhibitor to prevent respiration was added to one solution. The concentrations of potassium ions in the two solutions were measured at regular intervals. The graph shows the results.



(a) Explain the decrease in the concentrations of potassium ions in the two solutions between 0 and 30 minutes.

(i) With inhibitor

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(2)

(ii) Without inhibitor

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(1)

(b) Explain why there is no further decrease in the concentration of potassium ions in the solution with the inhibitor after 60 minutes.

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(2)

(c) The substance malonate is an inhibitor of respiration. It has a structure very similar to the substrate of an enzyme that catalyses one of the reactions of respiration. Explain how malonate inhibits respiration.

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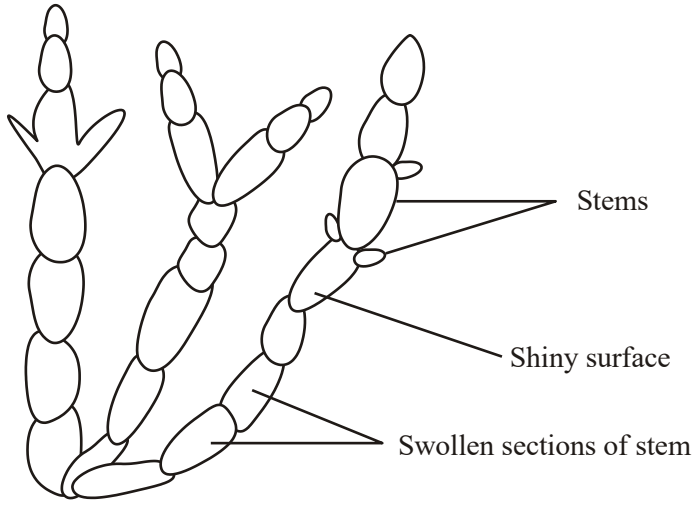
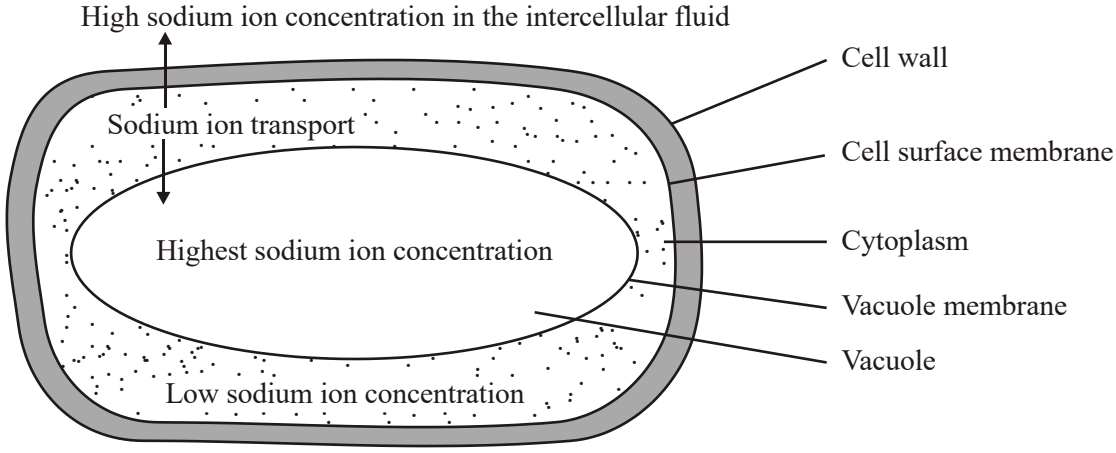
(2)

(Total 7 marks)

45. Glasswort is a plant that grows in salt marshes. The plants are covered by seawater at each high tide. The roots grow in mud which contains a high concentration of salt. The drawing shows a shoot of the plant.



In glasswort cells, sodium ions are transported from the cytoplasm outwards across the cell surface membrane and also into the cell vacuole. The concentration of sodium ions is greater inside the vacuole than in the intercellular fluid, which is the fluid between the cells in tissues. High sodium ion concentrations would disrupt metabolic processes in the cytoplasm. This information is summarised in the diagram below.



S (a) The total concentration of all ions in the cytoplasm is higher than in the intercellular fluid. Explain how this allows the cell to take up water.

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(2)

S (b) (i) Explain how sodium ions are transported through the membranes.

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(2)

(ii) There is a higher concentration gradient between the cytoplasm and the vacuole than between the cytoplasm and the intercellular fluid. Suggest how the vacuole membrane maintains this higher concentration gradient.

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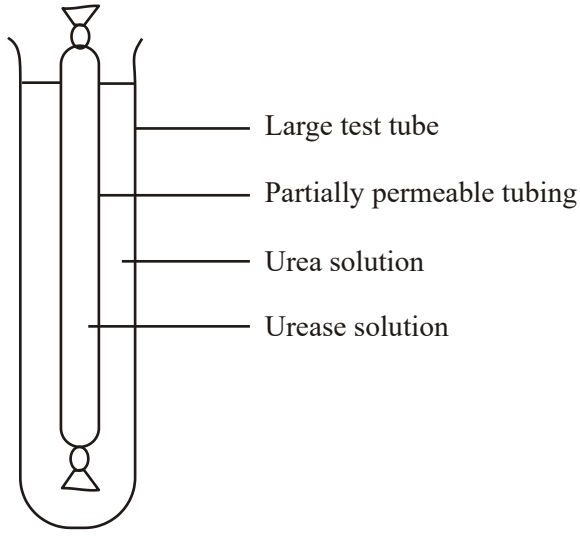
(2)

(Total 6 marks)

46. **S** Urease is an enzyme which hydrolyses urea to ammonia and carbon dioxide. The ammonia produces an alkaline solution.

In an experiment, a solution of urease was placed in tubing made from a partially permeable membrane. This tubing was put into a large test tube containing urea solution, as shown in the diagram. A control was set up with urease solution in the tubing and water outside.



After 5 minutes, samples were taken from inside and outside the tubing in each of the test tubes. The samples were tested with an indicator that is yellow below pH 8.0 and blue above pH 8.0. The results are shown in the table.

Tube	Contents		Colour with indicator after 5 minutes	
	Inside tubing	**Outside tubing**	**Inside tubing**	**Outside tubing**
A	Urease solution	Urea solution	Blue	Yellow
B	Urease solution	Water	Yellow	Yellow

(a) Explain the result for tube **A**.

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(3)

(b) The solutions inside and outside the tubing in tube **B** were tested after 30 minutes for the presence of protein.

(i) Describe how the presence of protein in a sample of a solution could be detected.

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(2)

(ii) What results of the tests for protein would you expect for tube **B**? In each case explain your answer.

Inside the tubing

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Outside the tubing

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(2)

(c) Describe how you would carry out an investigation to find the optimum temperature for the activity of urease.

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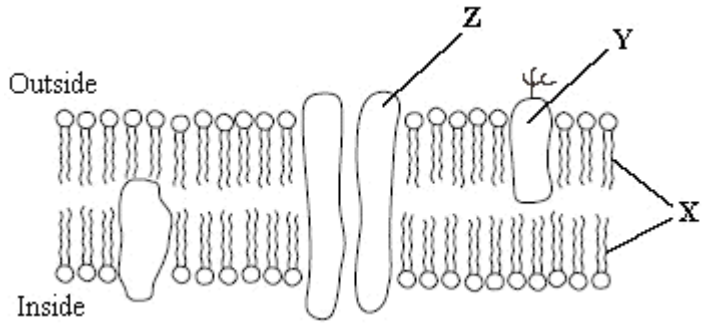
(3)

(Total 10 marks)

47. The diagram shows part of a plasma membrane.



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

1 .....

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2 .....

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(2)

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

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(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.

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

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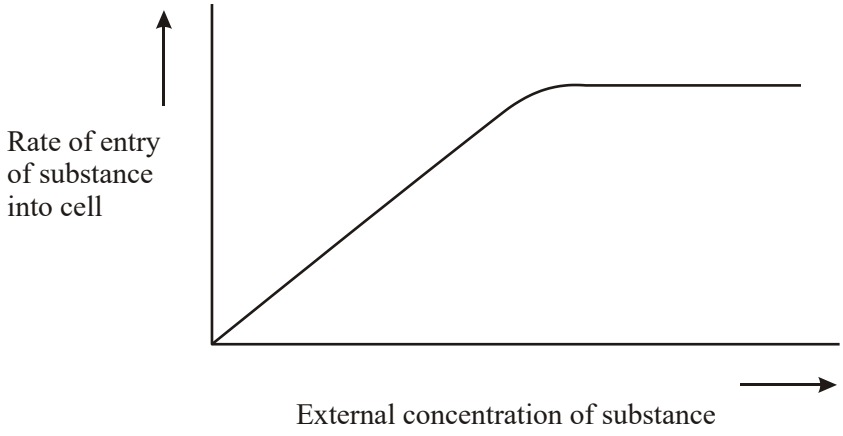
(2)

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



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

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(2)

(Total 7 marks)

48. Read the following passage

Cholera is a water-borne disease. It is caused by a bacterium. The bacterium produces a toxin which acts on the epithelial cells of the small intestine and causes changes in membrane permeability. The cholera toxin affects the movement of ions through the intestinal wall. It causes the loss of chloride ions from the blood into the lumen of the small intestine. This prevents the movement of sodium ions from the lumen of the small intestine into the blood. The resulting high concentration of ions causes diarrhoea.

Vaccination can produce immunity to cholera. A new vaccine appears to provide better immunity and has fewer side effects than previously available vaccines. This vaccine is taken orally. For long-term immunity, a booster dose is required after two years.

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

(a) The cholera toxin only affects the epithelial cells of the small intestine (line 2). Suggest why.

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(3)

(b) (i) Sodium ions normally enter the blood from cells of the intestinal wall against a concentration gradient. Describe how.

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(3)

(ii) The high concentration of ions in the small intestine of a person with cholera causes diarrhoea. (lines 6-7). Explain why.

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(2)

(c) The new vaccine for cholera is taken orally (line 10) but some vaccines are not taken orally. Suggest one reason why some vaccines are not taken orally.

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(1)

(d) A booster dose of vaccine is required to provide long-term immunity. Suggest why.

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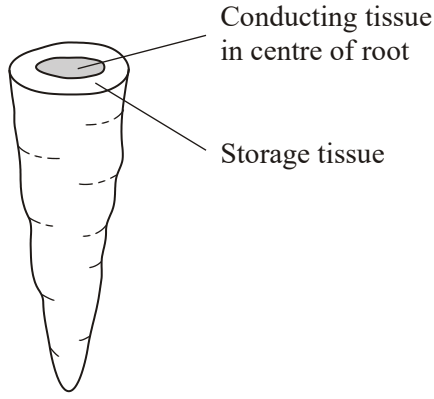
(1)

(Total 10 marks)

49. The diagram shows a carrot.



A group of students investigated the effect of sucrose concentration on the length of cylinders cut from a carrot.

(a) The students used a cork borer to cut cylinders from the carrot. Describe how the students should cut these cylinders to make sure that this was a fair test and would produce reliable results.

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(2)

(b) They measured the initial length of each cylinder then placed the cylinders into test tubes containing different concentrations of sucrose solution. Bungs were placed in the tubes and the tubes were left overnight. Explain why the bungs were placed in the tubes.

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(2)

(c) The students then measured the final lengths of the carrot cylinders. Their results are shown in the table.

Concentration of sucrose / mol dm^{-3}	$\frac{\textbf{Final length}}{\textbf{Initial length}}$
0.0	1.4
0.2	1.4
0.4	1.2
0.6	1.1
0.8	0.9

(i) The students used these results to find the concentration of sucrose that has the same water potential as the carrot cylinders. Describe how they could have done this.

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(2)

(ii) Was it important in this investigation that the carrot cylinders had the same initial length? Explain your answer.

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(1)

(Total 7 marks)