AQA, OCR, Edexcel

A Level

A Level Biology

Stimuli, Response and the Nervous System Questions

Name:

M M E

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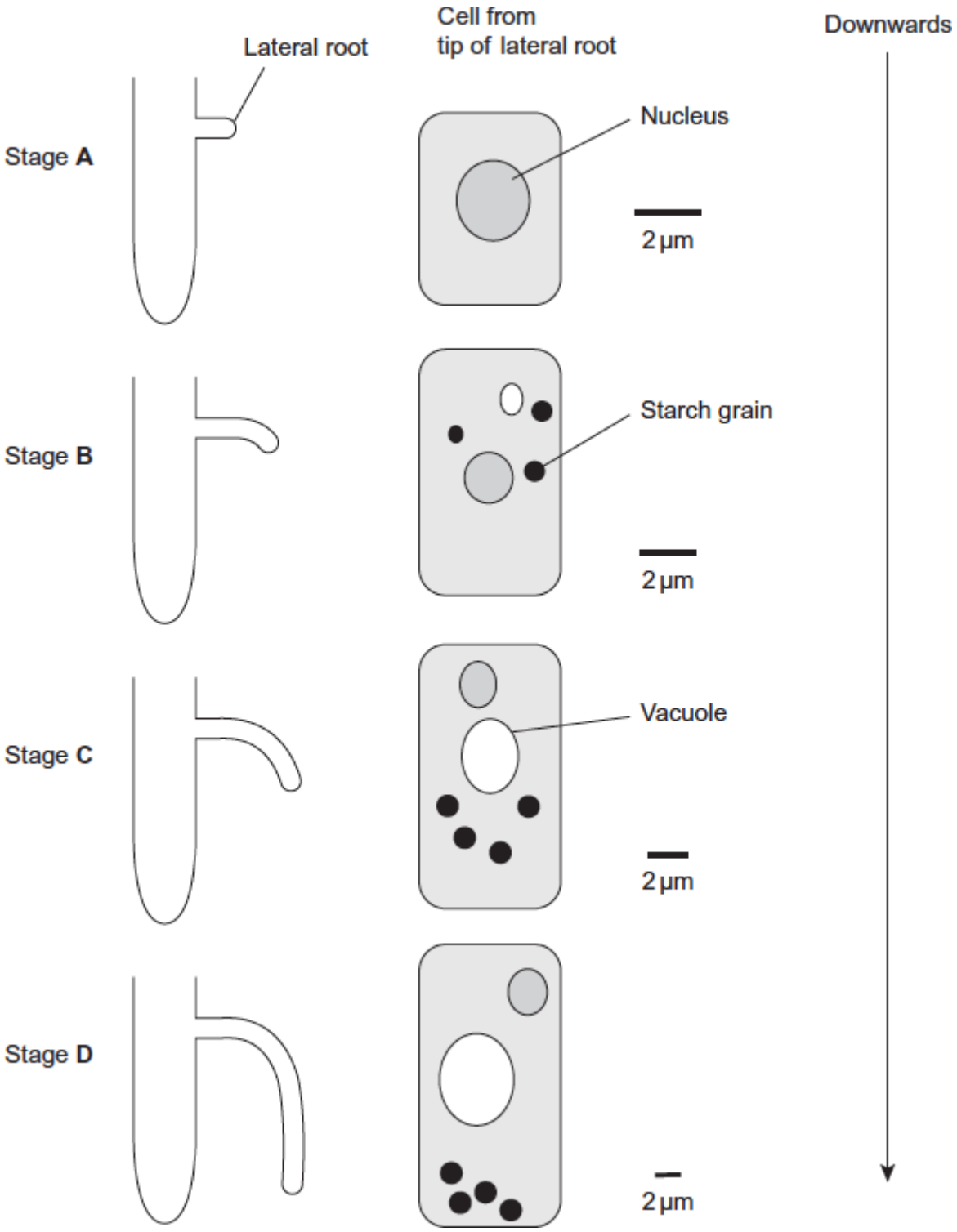
Total Marks:

Q1. Scientists investigated the response of lateral roots to gravity. Lateral roots grow from the side of main roots.

The diagrams show four stages, **A** to **D**, in the growth of a lateral root and typical cells from the tip of the lateral root in each stage. All of the cells are drawn with the bottom of the cell towards the bottom of the page.



(a) Describe **three** changes in the root tip cells between stages **A** and **D.**

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(b) The scientists' hypothesis was that there was a relationship between the starch grains in the root tip cells and the bending and direction of growth of lateral roots.

Does the information in the diagram support this hypothesis? Give reasons for your answer.

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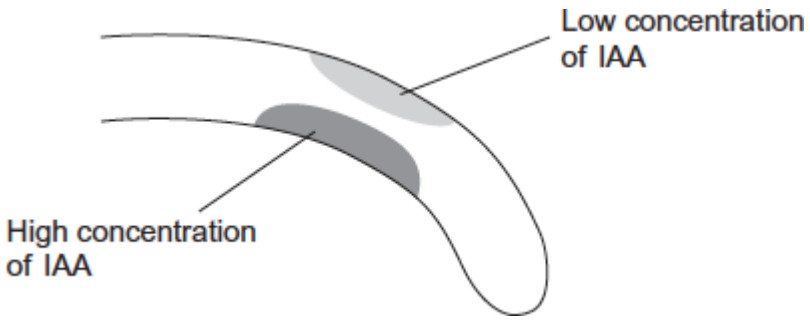
(c) The diagram shows the distribution of indoleacetic acid (IAA) in the lateral root at Stage **B.**



Explain how this distribution of IAA causes the root to bend.

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Q2. A biologist investigated the behaviour of a species of worm that lives in soil.

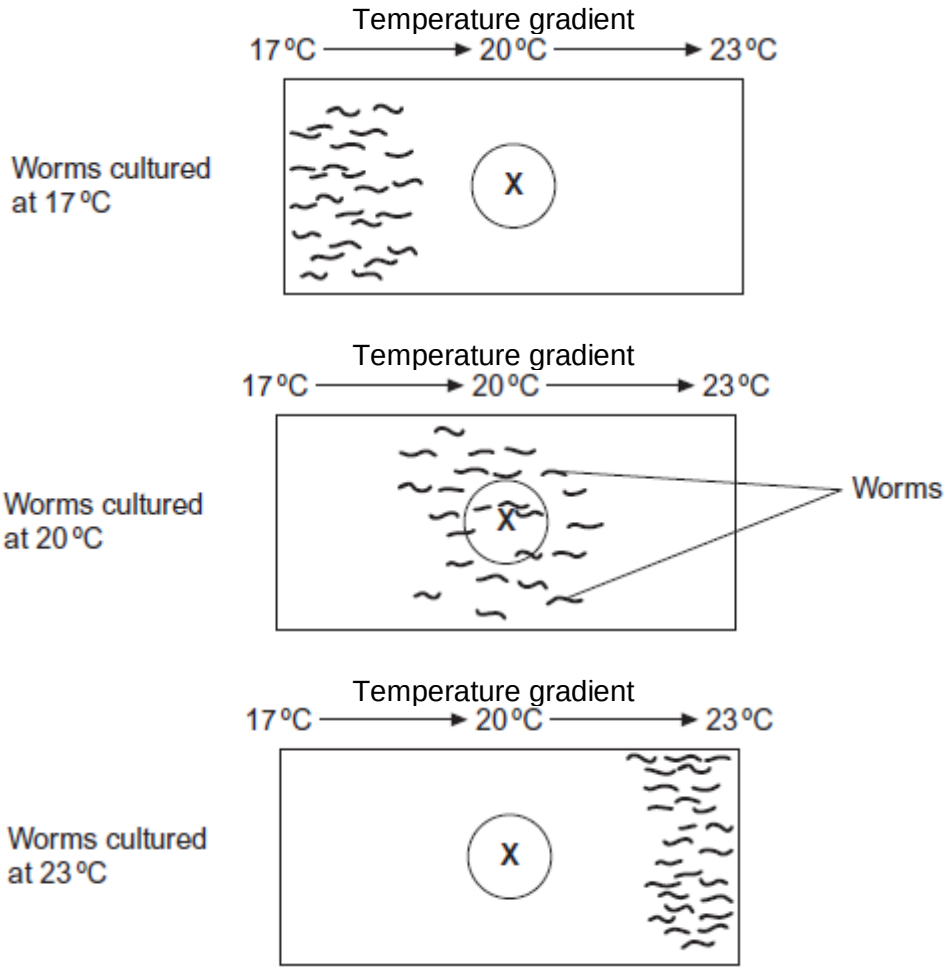
He cultured three samples of worms in three separate trays of soil for many days. Each culture:

- contained a food supply
- was kept at a different temperature.

The temperatures of the cultures were 17 °C, 20 °C and 23 °C.

The biologist then removed food from the trays for several hours. Then he transferred each sample of worms onto a glass surface where there was **no food**. Each surface had a temperature gradient across it. After 1 hour, the biologist recorded the position of each worm.

The figure below shows his results. On each diagram, X marks where he released the worms onto the glass surface.



(a) The biologist concluded that the worms' behaviour demonstrated taxis.
How do these results support this conclusion?

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(b) Using the information provided, suggest an explanation for the worms' behaviour on the glass surfaces in the absence of food.

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(c) In each experiment, the biologist exposed the surfaces to light that was dim and even, so he could see where the worms went.

Apart from seeing where the worms went, suggest **two** reasons why it was important that the light was dim and even.

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(2)
(Total 7 marks)

Q3.(a) Describe how a Pacinian corpuscle produces a generator potential when stimulated.

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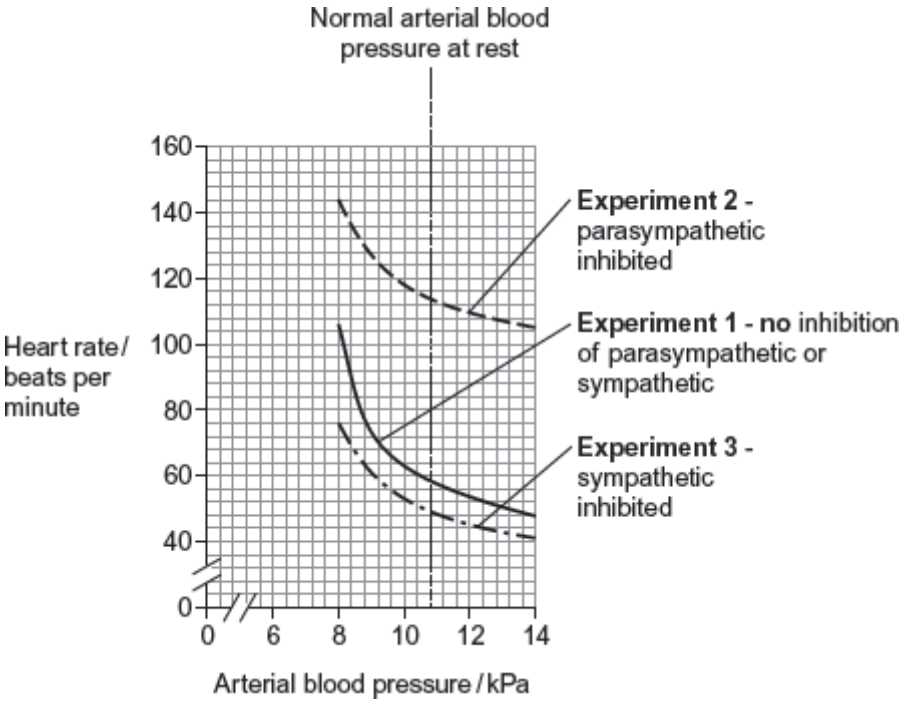
(3)

Doctors investigated the relationship between heart rate and arterial blood pressure. They recruited healthy volunteers. For each volunteer, they recorded their normal arterial blood pressure at rest. With each volunteer, they then carried out the following experiments.

Experiment 1	They recorded heart rate at different blood pressures.
Experiment 2	They repeated **experiment 1** after injecting a drug that inhibited the parasympathetic nervous system.
Experiment 3	They repeated **experiment 1** after injecting a drug that inhibited the sympathetic nervous system.

The graph shows the results for one volunteer.



(b) Calculate the ratio of heart rate in **experiment 2** to heart rate in **experiment 3** at an arterial blood pressure of 10 kPa.
Show your working.

Answer = ...

(2)

(c) What do these data suggest about the control of heart rate by the parasympathetic and sympathetic nervous systems in response to changes in arterial blood pressure?

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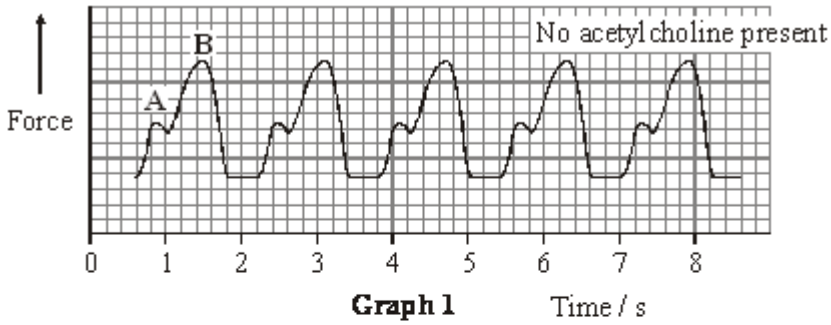
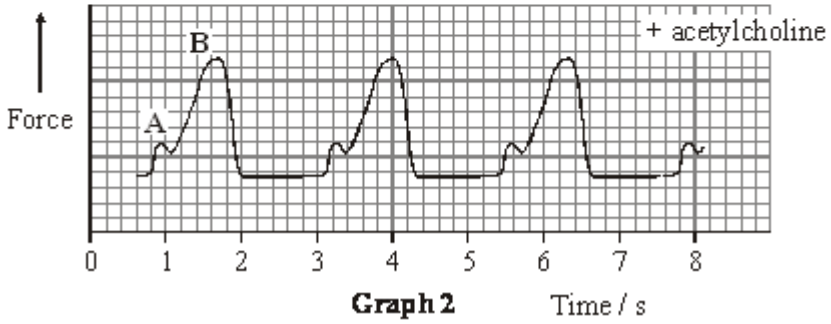
(Total 8 marks)

Q4. A frog's heart was attached to an instrument which measured the force produced as the heart contracted. **Graph 1** shows the changes in force when the heart was bathed in a solution of salts at 20 °C. **Graph 2** shows the results when the heart was bathed in the same solution at the same temperature, but including acetylcholine.



Graph 1



Graph 2

(a) Points **A** and **B** show when the atria and ventricle were contracting. Which point, **A** or **B**, shows contraction of the ventricle? Give **two** reasons for your answer.

Point .....

Reason 1 .....

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Reason 2 .....

.....**(2)**

(b) Calculate the frog's heart rate when acetylcholine was **not** present. Show your working.

Heart rate = ... beats per minute.

(2)

(c) (i) From the graphs, what can you conclude about the effect of acetylcholine on

heart rate;

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stroke volume?

.....**(2)**

(ii) Use your answer to part (i) to explain the effect of acetylcholine on cardiac output.

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.....**(1)**

(iii) Addition of acetylcholine in the experiment mimics the effect of one branch of the autonomic nervous system. Which branch is this?

.....**(1)**

(d) (i) Explain how nervous control in a human can cause increased cardiac output during exercise.

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(ii) Explain why increased cardiac output is an advantage during exercise.

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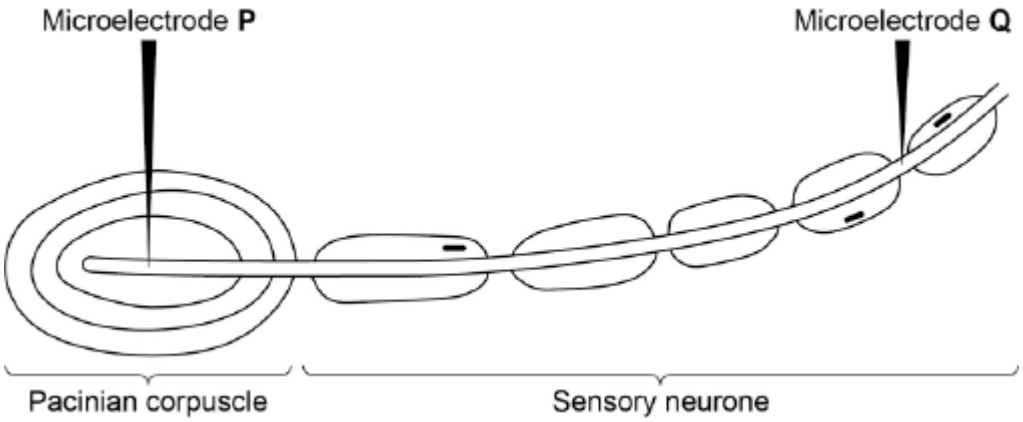
Q5. A biologist investigated the stimulation of a Pacinian corpuscle in the skin of a fingertip. She used microelectrodes to measure the maximum membrane potential of a Pacinian corpuscle and its sensory neurone when different pressures were applied to the fingertip.

The figure below shows the Pacinian corpuscle, its sensory neurone and the position of the microelectrodes.



The table below shows some of the biologist's results.

Pressure applied to the fingertip	Membrane potential at P / millivolts	Membrane potential at Q / millivolts
None	–70	–70
Light	–50	–70
Medium	+30	+40
Heavy	+40	+40

(a) Explain how the resting potential of –70 mV is maintained in the sensory neurone when no pressure is applied.

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(b) Explain how applying pressure to the Pacinian corpuscle produces the changes in membrane potential recorded by microelectrode **P**.

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(c) The membrane potential at **Q** was the same whether medium or heavy pressure was applied to the finger tip. Explain why.

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(d) Multiple sclerosis is a disease in which parts of the myelin sheaths surrounding neurones are destroyed. Explain how this results in slower responses to stimuli.

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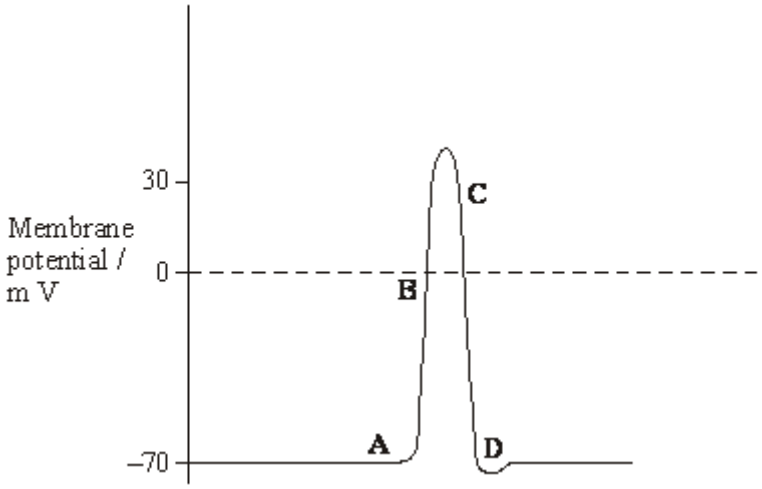
(Total 9 marks)

Q6. (a) **Figure 1** shows the changes in membrane potential at one point on an axon when an action potential is generated.

Figure 1



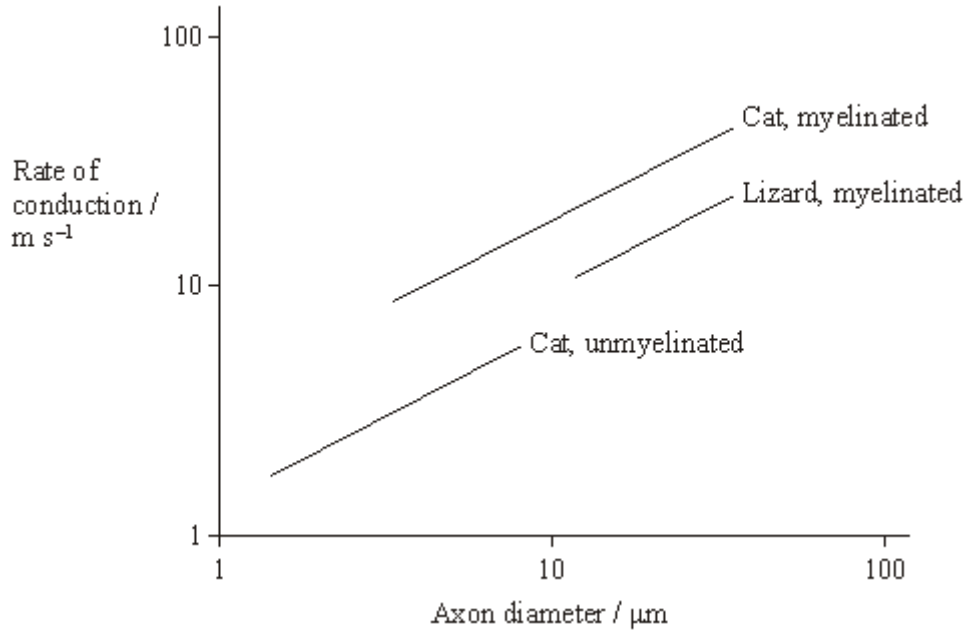
The changes shown in **Figure 1** are due to the movement of ions across the axon membrane. Complete the table by giving the letter (**A** to **D**) that shows where each process is occurring most rapidly.

Process	Letter
Active transport of sodium and potassium ions	
Diffusion of sodium ions	
Diffusion of potassium ions	

(2)

(b) **Figure 2** shows the relationship between axon diameter, myelination and the rate of conduction of the nerve impulse in a cat (a mammal) and a lizard (a reptile).

Figure 2



(i) Explain the effect of myelination on the rate of nerve impulse conduction.

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.....**(2)**

(ii) For the same diameter of axon, the graph shows that the rate of conduction of the nerve impulse in myelinated neurones in the cat is faster than that in the lizard. Suggest an explanation for this.

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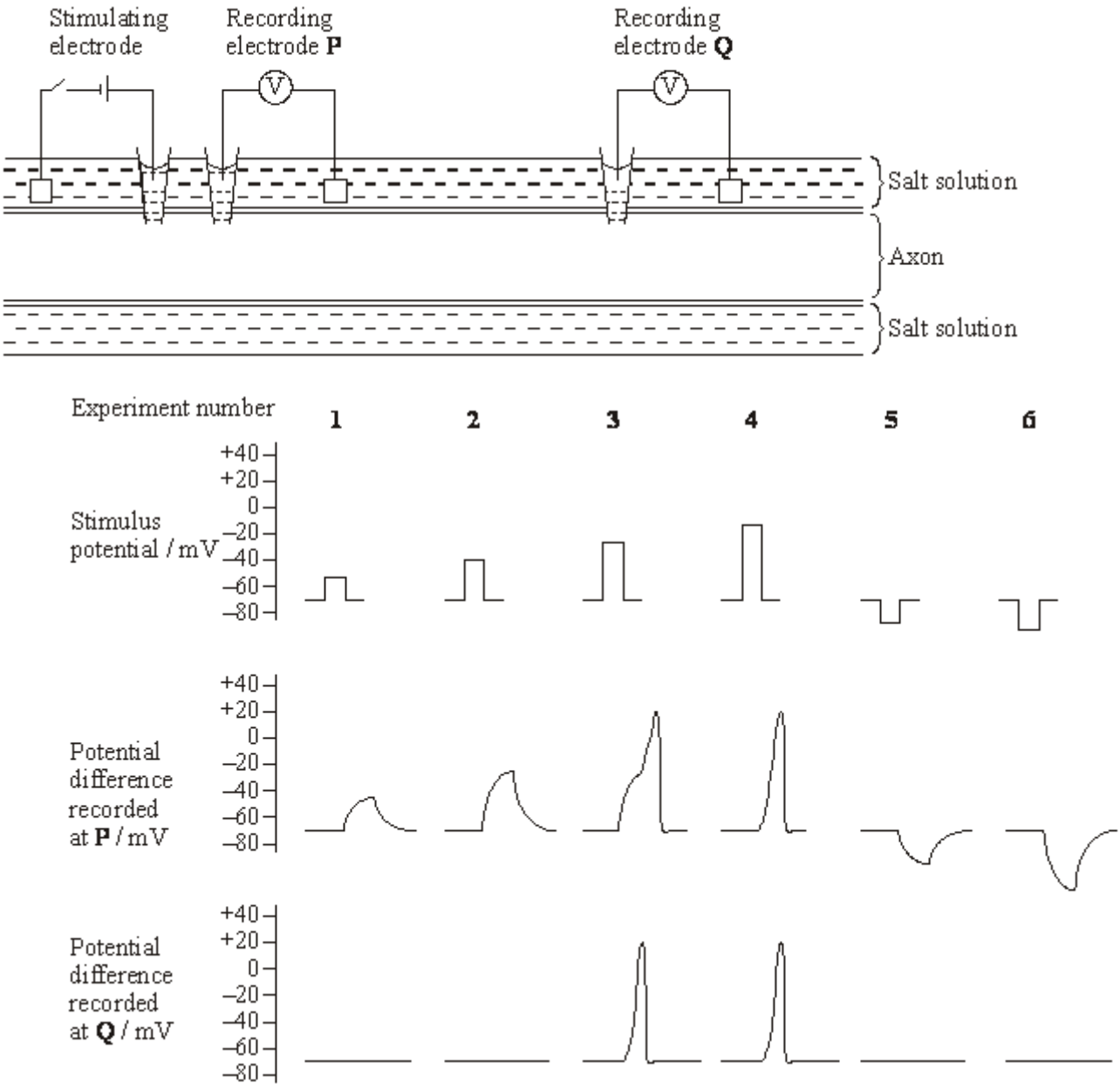
.....**(2)**

Figure 3 shows how a stimulating electrode was used to change the potential difference across an axon membrane. Two other electrodes, **P** and **Q**, were used to record any potential difference produced after stimulation. The experiment was repeated six times, using a different stimulus potential each time. In experiments **1** to **4**, the stimulating voltage made the inside of the axon less negative. In experiments **5** and **6**, it made the inside of the axon more negative.

Figure 3



(c) Explain the results of experiments **1** to **4**.

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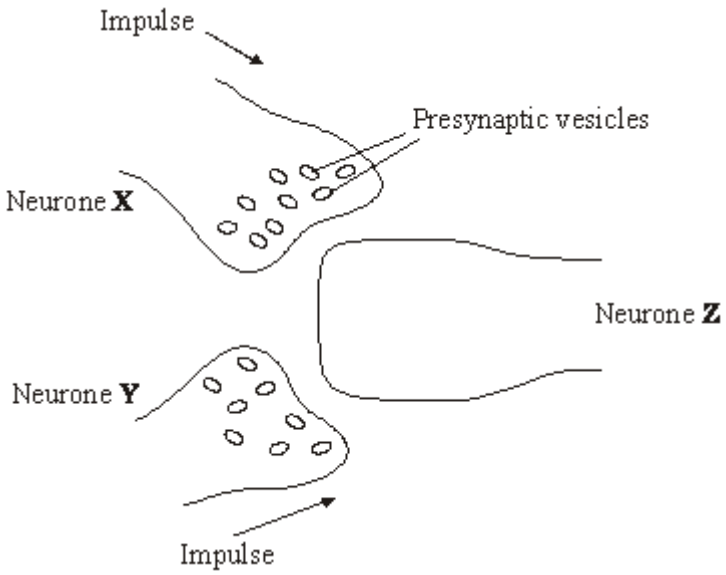
(d) **Figure 4** shows two neurones, **X** and **Y**, which each have a synapse with neurone **Z**.

Figure 4



Neurone **X** releases acetylcholine from its presynaptic vesicles. Neurone **Y** releases a different neurotransmitter substance which allows chloride ions (Cl^-) to enter neurone **Z**. Use this information, and information from **Figure 3**, to explain how neurones **X** and **Y** have an antagonistic effect on neurone **Z**.

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(Total 15 marks)

Q7. (a) Describe how calcium ions are involved in synaptic transmission.

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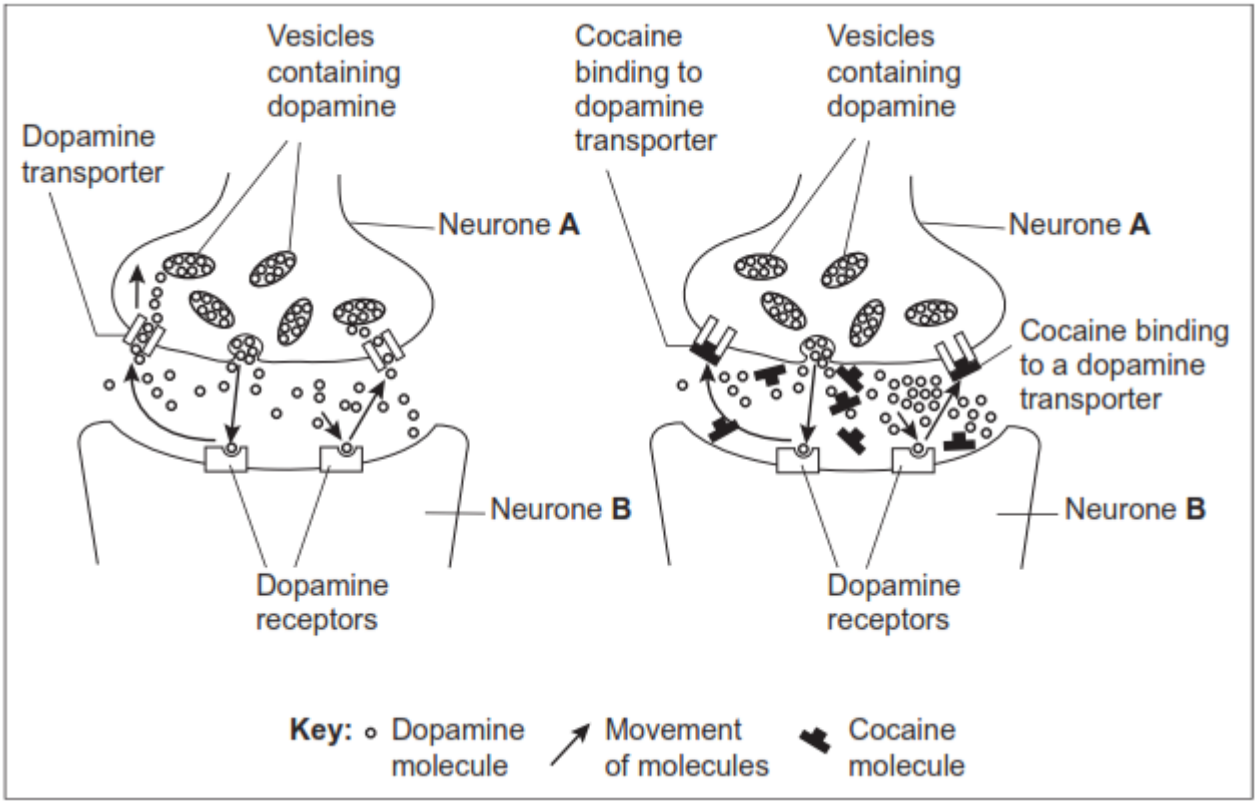
Cocaine changes the way some synapses function.
Figure 1 shows a synapse in part of the brain. This synapse uses a neurotransmitter called dopamine.

Figure 1



(b) This synapse only transmits information from neurone **A** to neurone **B** and not from **B** to **A**. Give **one** reason why.

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(1)

(c) **Figure 2** shows the structures of molecules of dopamine and cocaine.

Figure 2

(i) Explain why cocaine is able to bind to the dopamine transporter, as shown in **Figure 1**.

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.....**(2)**

(ii) Dopamine is released at synapses in parts of the brain where pleasure is perceived. Using information from **Figures 1** and **2**, explain how the use of cocaine can result in feelings of pleasure.

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(Total 8 marks)

Q8. Serotonin is a neurotransmitter released in some synapses in the brain. It is transported back out of the synaptic gap by a transport protein in the pre-synaptic membrane.

(a) Serotonin diffuses across the synaptic gap and binds to a receptor on the post-synaptic membrane. Describe how this causes depolarisation of the post-synaptic membrane.

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(2)

(b) It is important that a neurotransmitter such as serotonin is transported back out of synapses. Explain why.

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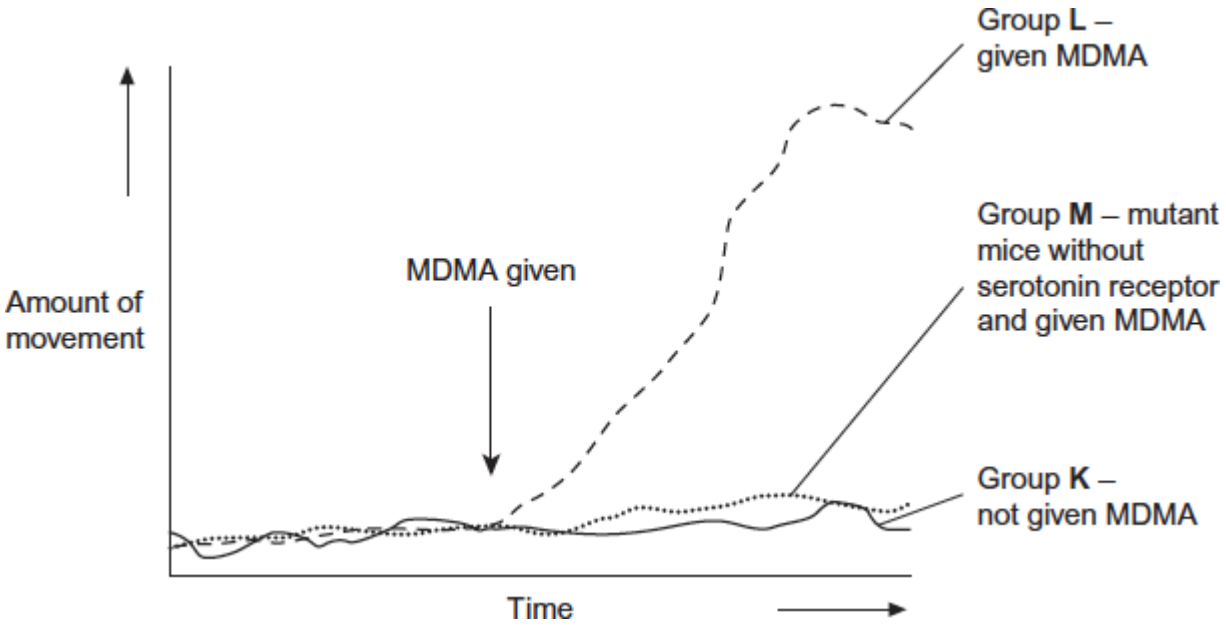
(c) Scientists investigated the effect of a drug called MDMA on movement of mice. They measured the amount of movement of three groups of mice, **K, L** and **M.**

- Group **K,** mice not given MDMA.
- Group **L,** mice given MDMA.
- Group **M,** mutant mice that did not produce a serotonin receptor on their post-synaptic membranes and were given MDMA.

The graph shows their results.



The scientists concluded that MDMA affects movement by binding to serotonin receptors. How do these results support this conclusion?

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(3)
(Total 7 marks)

Q9.(a) A myelinated axon conducts impulses faster than a non-myelinated axon.
Explain this difference.

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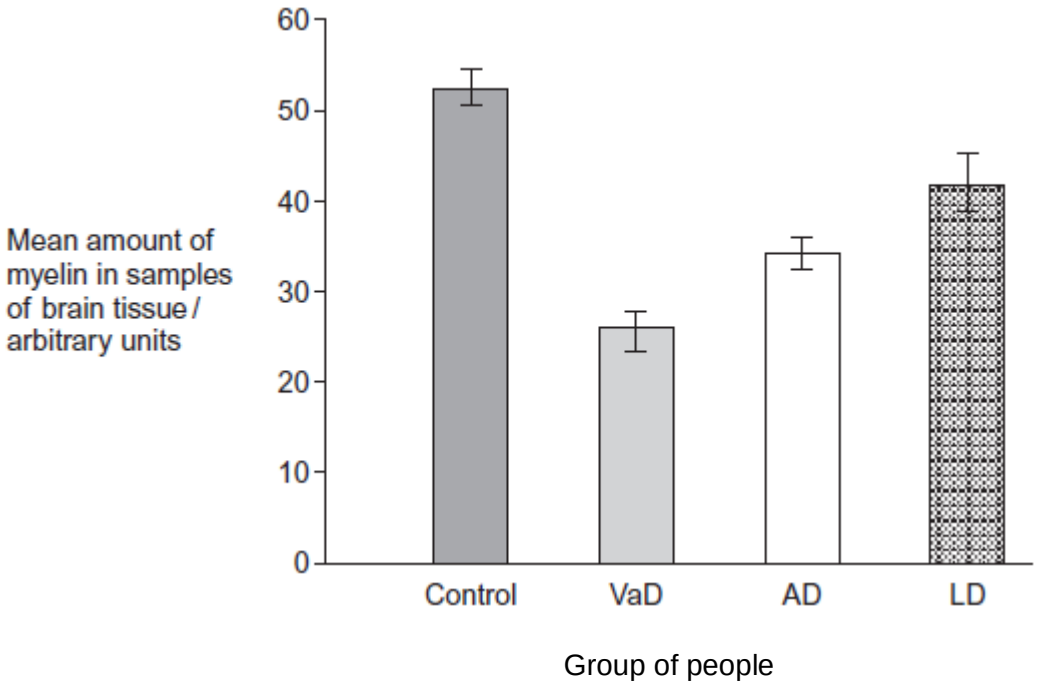
Doctors investigated the relationship between myelin in brain tissue and different types of dementia. All types of dementia involve loss of mental ability.

The doctors measured the mean amount of myelin in samples of brain tissue from:

- a control group of 12 people without dementia
- 20 people with vascular dementia (VaD)
- 19 people with Alzheimer's dementia (AD)
- 31 people with Lewy body dementia (LD).

The doctors' results are shown in the figure. The vertical bars show standard errors.



(b) The doctors used a statistical test to compare the results for AD and LD. They obtained a value for P of 0.047.

What does this result show about the difference between the means for AD and LD?

Use the words **probability** and **chance** in your answer.

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.....**(2)**

(c) A student who read this investigation concluded that there was a relationship between the amount of myelin in a person's brain and whether or not they had dementia. Do these data support this conclusion? Give reasons for your answer.

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.....**(4)**

(Total 9 marks)

Q10.(a) Give **one** similarity and **one** difference between a taxis and a tropism.

Similarity.....

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Difference .....

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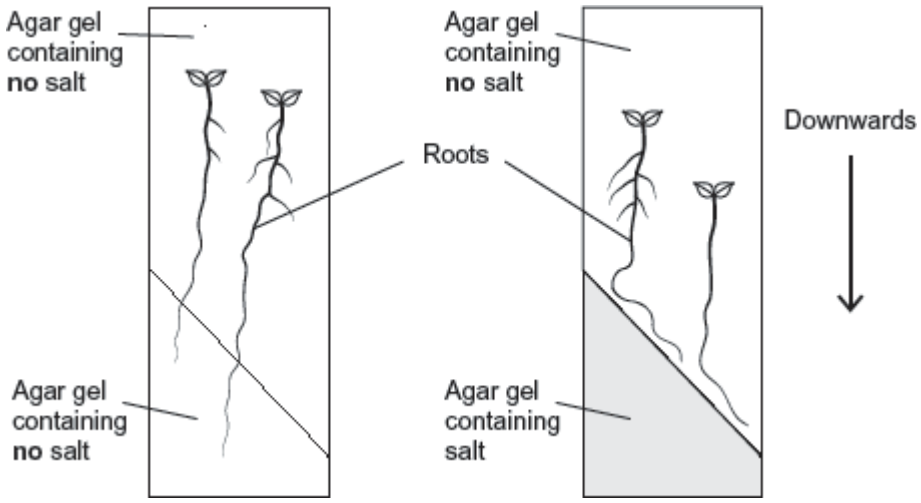
(2)

Scientists investigated tropisms in the roots of tomato plants. They grew tomato plants from seeds on vertical agar plates, as shown in **Figure 1**. The top of each plate was made of agar gel containing **no** salt. The bottom of each plate was made of one of the following:

- agar gel containing **no** salt
- agar gel containing salt.

Typical results for growth of the roots are shown in **Figure 1**.

Figure 1



(b) What do these results show about the responses of the roots of tomato plants to gravity and salt?

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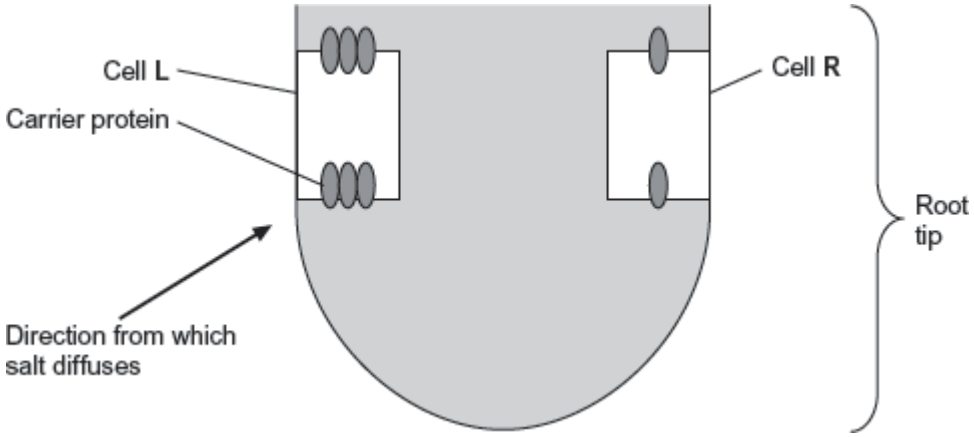
..... **(3)**

(c) In root tips of tomatoes, IAA is transported **out** of the cells by a carrier protein. In roots of tomatoes, high concentrations of IAA inhibit cell elongation.

The scientists' hypothesis was that salt causes a change in the number of IAA carrier proteins in cells in different parts of the root tip.

Figure 2 shows two cells, **L** and **R**, in the root tip of a tomato plant.

Figure 2



Explain why this root tip would grow away from salt.

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(3)
(Total 8 marks)

Q11. Multiple sclerosis (MS) is a disease that involves damage to the myelin sheaths of neurones. Movement in MS sufferers may be jerky or slow.

(a) Damage to the myelin sheaths of neurones can lead to problems controlling the contraction of muscles. Suggest **one** reason why.

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..... **(2)**

Scientists investigated the use of substances called cannabinoids to control muscle problems caused by MS.

(b) Cannabinoids are hydrophobic molecules. In the body, they easily pass into neurones. Explain why.

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..... **(1)**

(c) Cannabinoid receptors are found in the **pre-synaptic** membrane of neuromuscular junctions. When a cannabinoid binds to its receptor, it closes calcium ion channels.

Suggest how cannabinoids could prevent muscle contraction.

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(d) Cannabinoids include substances found in cannabis that can enter brain tissue. Scientists are developing artificial cannabinoids that can enter neuromuscular junctions but cannot enter brain tissue.

Suggest why these artificial cannabinoids would be better to use than cannabis when treating someone with MS.

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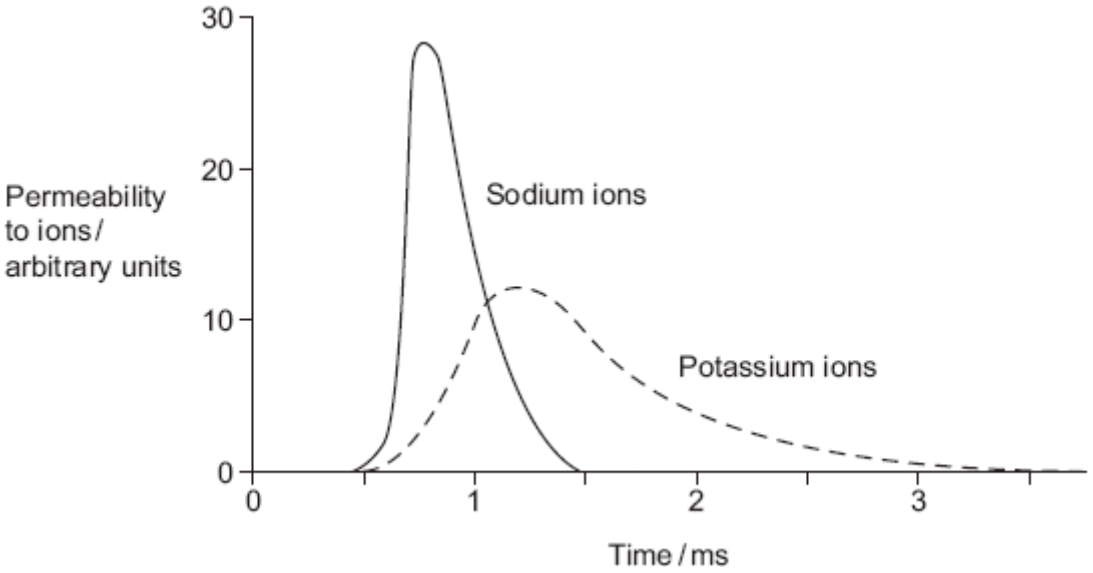
..... **(2)**

(Total 9 marks)

Q12. During an action potential, the permeability of the cell-surface membrane of an axon changes. The graph shows changes in permeability of the membrane to sodium ions (Na^+) and to potassium ions (K^+) during a single action potential.



(a) Explain the shape of the curve for sodium ions between 0.5 ms and 0.7ms.

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(b) During an action potential, the membrane potential rises to +40 mV and then falls. Use information from the graph to explain the fall in membrane potential.

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.....**(3)**

(c) After exercise, some ATP is used to re-establish the resting potential in axons.
Explain how the resting potential is re-established.

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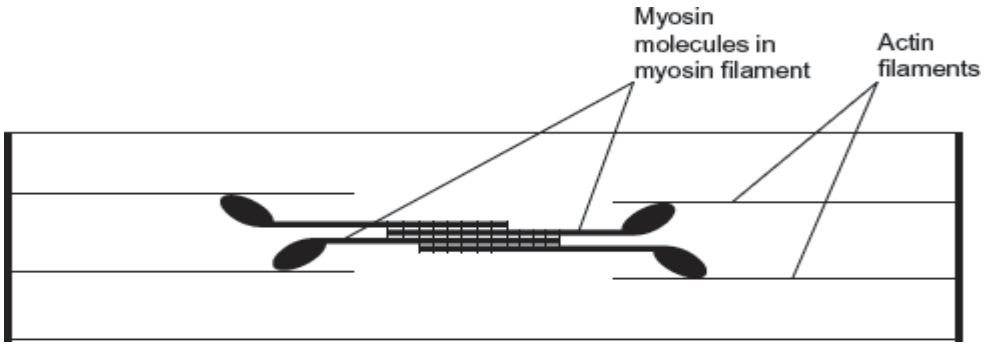
(2)
(Total 8 marks)

Q13.(a) A sarcomere is made up of different molecules.
Complete the table by naming the molecule that carries out the function described.

Function	**Name**
Attaches to Z line at the end of the sarcomere	
Breaks down ATP	
Covers binding site on actin in relaxed myofibril	

(3)

(b) The diagram shows the arrangement of actin and myosin in a sarcomere.



One form of muscle disease is caused by a mutated allele of a gene. This leads to production of myosin molecules that are unable to bind to other myosin molecules.

If myosin molecules are unable to bind to other myosin molecules, this prevents muscle contraction.
Use the diagram and your knowledge of how muscles contract to suggest why.

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(3)
(Total 6 marks)

Q14. Researchers investigated whether the blood supply to slow and fast muscle fibres in a muscle changes with age. They used diaphragms taken from hamsters (*Mesocricetus auratus*). The diaphragm is in constant use for breathing. They took diaphragms from groups of young, adult and old hamsters.

They removed the diaphragm from each animal and took a sample of muscle tissue.They examined it under an optical (light) microscope. For each sample they selected several fields of view at random. In each field of view, they then counted the number of capillaries associated with each type of muscle fibre.

This allowed the researchers to calculate the mean number of capillaries for each type of muscle fibre, for each age group.

The table below shows the researchers' results which include standard deviation (SD).

Hamster age group	**Number of hamsters in group**	**Mean number of capillaries associated with each type of muscle fibre**	
		Slow fibres (± SD)	**Fast fibres (± SD)**
Young	9	3.4 (±0.8)	4.0 (±0.8)
Adult	10	4.7 (±0.2)	6.3 (±0.4)
Old	8	4.6 (±0.9)	6.8 (±0.6)

(a) Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

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(4)

(b) The researchers examined the muscle of an animal in the **old** age group. They found one field of view containing only slow muscle fibres. They counted 69 capillaries in this field of view.

(i) Use a calculation to estimate how many slow muscle fibres were visible in this field of view. Show your working.

Number of slow muscle fibres = ...**(2)**

(ii) The actual number of slow muscle fibres in the field of view was **not** the same as the number you calculated in question (i).

Give **one** reason why.

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.....**(1)**

(c) A student read the report of the researchers' investigation. She thought that the investigation was unethical but that a conclusion could still be made.

(i) Suggest why she thought the investigation was unethical.

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(ii) She concluded that age had a significant effect on the mean number of capillaries per fibre. Evaluate this conclusion.

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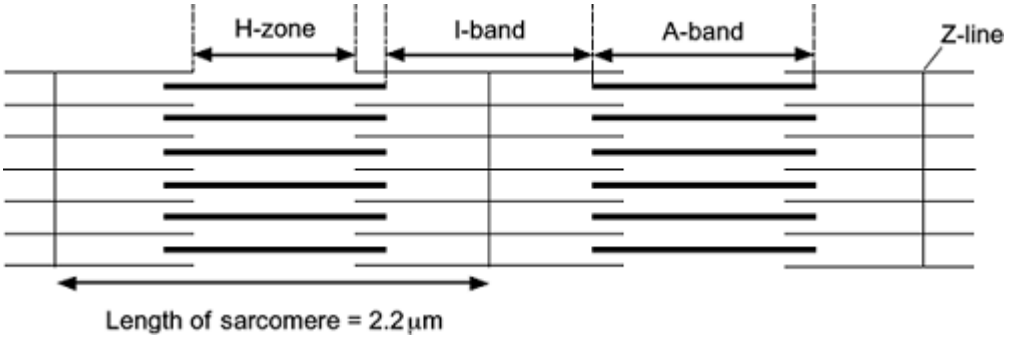
(Total 12 marks)

Q15. The diagram shows two relaxed sarcomeres from skeletal muscle.



(a) When the sarcomeres contract, what happens to the length of

(i) the I-band

.....**(1)**

(ii) the A-band?

.....**(1)**

(b) The length of each sarcomere in the diagram is 2.2 μm. Use this information to calculate the magnification of the diagram. Show your working.

Magnification .....**(2)**

(c) People who have McArdle's disease produce less ATP than healthy people. As a result, they are not able to maintain strong muscle contraction during exercise. Use your knowledge of the sliding filament theory to suggest why.

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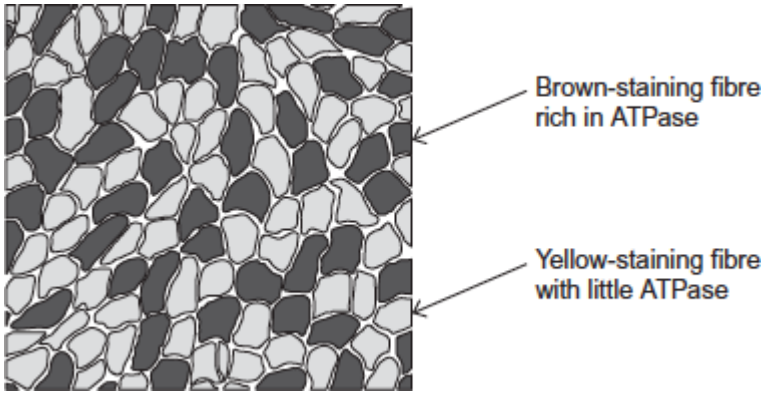
(3)
(Total 7 marks)

Q16. Slow and fast skeletal muscles both contain slow and fast muscle fibres but in different proportions. The proportion can be determined by observing stained sections of muscle under a microscope. The stain used reacts with an ATPase enzyme. Muscle fibres containing a lot of this ATPase stain brown. Fibres containing little ATPase stain yellow.

The diagram shows stained muscle fibres in a section taken from a muscle.



(a) Both slow and fast muscle fibres contain ATPase.

Explain why.

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(b) The tissue in the diagram came from muscle with a high proportion of brown-staining fibres. Was the tissue removed from slow or fast skeletal muscle?

Explain your answer.

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(c) The muscle tissue in the diagram had been stained for viewing with a microscope.

What is the evidence that it had been stained for viewing with an optical (light) microscope? Explain your answer.

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(2)
(Total 5 marks)

Q17. Osmoreceptors are specialised cells that respond to changes in the water potential of the blood.

(a) Give the location of osmoreceptors in the body of a mammal.

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.....**(1)**

(b) When a person is dehydrated, the cell volume of an osmoreceptor decreases. Explain why.

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(c) Stimulation of osmoreceptors can lead to secretion of the hormone ADH. Describe and explain how the secretion of ADH affects urine produced by the kidneys.

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The efficiency with which the kidneys filter the blood can be measured by the rate at which they remove a substance called creatinine from the blood. The rate at which they filter the blood is called the glomerular filtration rate (GFR).

In 24 hours, a person excreted 1660 mg of creatinine in his urine. The concentration of creatinine in the blood entering his kidneys was constant at 0.01 mg cm^{-3}.

(d) Calculate the GFR in cm^3 $minute^{-1}$.

Answer = ...

(1)

(e) Creatinine is a breakdown product of creatine found in muscle tissues. Apart from age and gender, give **two** factors that could affect the concentration of creatinine in the blood.

1 .....

2 .....

(1)

(Total 9 marks)

Q18. Scientists investigated the control of blood glucose concentration in mice. They kept a group of normal mice without food for 48 hours. After 48 hours, the blood glucose concentrations of the mice were the same as at the start of the experiment.

(a) Explain how the normal mice prevented their blood glucose concentration falling when they had **not** eaten for 48 hours.

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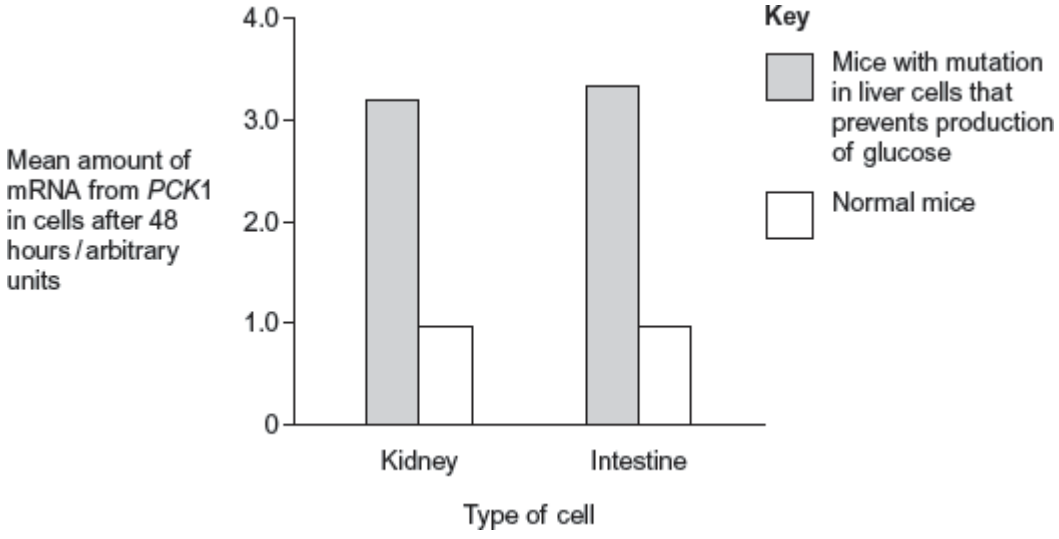
The scientists then investigated mice with a mutation that prevents their liver cells making glucose. They kept a group of these mice without food for 48 hours. After 48 hours, the mean blood glucose concentrations of the mutant mice and the normal mice were the same.

The scientists investigated how blood glucose concentration is controlled in these mutant mice. An enzyme required for synthesis of glucose is coded for by a gene called *PCK*1. The scientists measured the mean amount of mRNA produced from this gene in cells from the kidneys and intestines of normal mice and mutant mice. They did this with mice that had previously been without food for 48 hours.

The scientists' results are shown in the graph.



(b) Use information from the graph to suggest how blood glucose concentration is controlled in the mutant mice, compared with the normal mice.

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(c) The scientists performed statistical tests on the data shown in the graph, to see whether the differences in the amount of mRNA in cells from normal and mutant mice were significant. Both the probability values they obtained were $p<0.01$.

Explain what this means about the differences in the amounts of mRNA produced.

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(Total 8 marks)

Q19. There are two types of diabetes: type 1 and type 2.

- People with type 1 diabetes do not produce enough insulin.
- People with type 2 diabetes do produce insulin but have cells which do not respond to insulin.

Doctors use a glucose tolerance test to help diagnose people with diabetes. They start each test after a person has not eaten overnight. They measure a person's blood glucose concentration.
The person then drinks a solution containing 75 g of glucose. The doctors measure the person's blood glucose concentration 2 hours later. During the test, the person remains at rest.

Figure 1 shows three diagnoses that can be made from the results of the test.

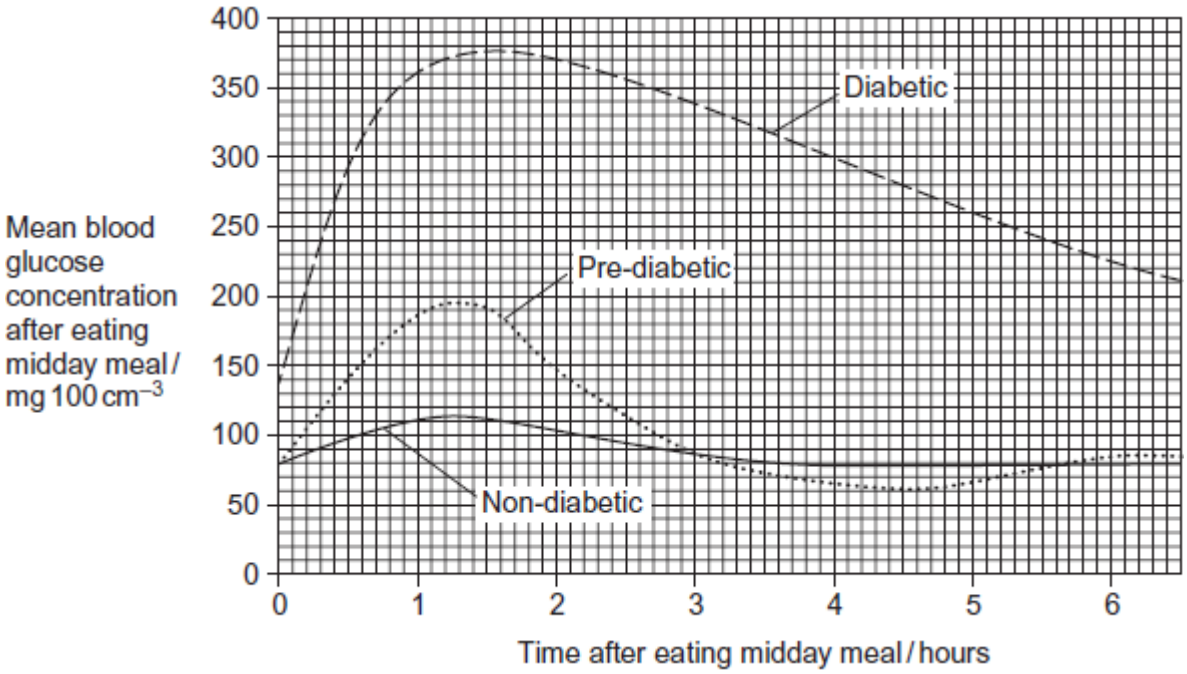
Figure 1 – glucose tolerance test results and diagnoses

Blood glucose concentration after 2 hours / mg 100 cm^{-3}	**Diagnosis**	**Comments**
≤ 110	Non-diabetic	Low risk for future diabetes
Between 140 and 200	Pre-diabetic	High risk for future diabetes. Some doctors recommend that the upper value should be lowered to 180 mg 100 cm^{-3}
≥ 200	Diabetic	Confirm by doing a second test

A researcher monitored the mean blood glucose concentration of a non-diabetic, a pre-diabetic and a diabetic after they had each eaten a midday meal.

His results are shown in **Figure 2**.

Figure 2



(a) People with type 1 diabetes are described as being insulin-dependent.
Suggest why they are described as insulin-dependent.

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(b) Some people with type 2 diabetes have cells which do **not** respond to insulin.
Explain how this leads to a reduced ability to regulate blood glucose concentration.

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(c) During a glucose tolerance test the person remains at rest.
Why is it important that the person remains at rest?

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(d) Use **Figure 2** to calculate how many times the maximum mean blood glucose concentration of the pre-diabetic is greater than the maximum of the non-diabetic person. Show your working.

Answer = ...**(2)**

(e) Give **three** differences between the method used by the researcher to obtain the results in **Figure 2** and the method doctors use to carry out a glucose tolerance test.

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(f) Some doctors have recommended that the upper value used in the glucose tolerance test should be lowered to 180 mg 100 cm^{-3}.
Using information from **Figure 1** and **Figure 2**, suggest why.

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(Total 14 marks)

Q20.(a) A diabetic person and a non-diabetic person each ate the same amount of glucose. One hour later, the glucose concentration in the blood of the diabetic person was higher than that of the non-diabetic person. Explain why.

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(b) (i) The urine of a non-diabetic person does **not** contain glucose. Explain why.

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(ii) A high blood glucose concentration could cause glucose to be present in the urine of a diabetic person. Suggest how.

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(c) A test for glucose in urine uses immobilised enzymes on a plastic test strip. One of these enzymes is glucose oxidase. Explain why the test strip detects glucose and no other substance.

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(d) If the glomerular filtrate of a diabetic person contains a high concentration of glucose, he produces a larger volume of urine. Explain why.

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(e) In some forms of kidney disease, proteins from the blood plasma are found in the urine. Which part of the nephron would have been damaged by the disease to cause proteins from blood plasma to be present in the urine? Explain your answer.

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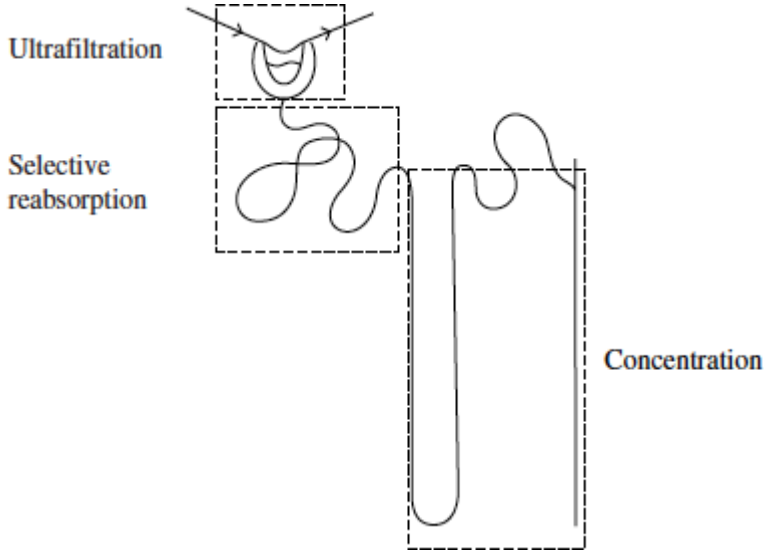
(Total 15 marks)

Q21. Three processes are involved in the formation of urine in a mammalian kidney. These are ultrafiltration, selective reabsorption and concentration. The diagram shows where these processes take place in a nephron.



(a) Describe how ultrafiltration produces glomerular filtrate.

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(b) Some people who have diabetes do not secrete insulin. Explain how a lack of insulin affects reabsorption of glucose in the kidneys of a person who does not secrete insulin.

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(c) Some desert mammals have long loops of Henle and secrete large amounts of antidiuretic hormone (ADH). Explain how these two features are adaptations to living in desert conditions.

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(Total 15 marks)

Q22.(a) When insulin binds to receptors on liver cells, it leads to the formation of glycogen from glucose. This lowers the concentration of glucose in liver cells.

Explain how the formation of glycogen in liver cells leads to a lowering of blood glucose concentration.

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People with type II diabetes have cells with low sensitivity to insulin. About 80% of people with type II diabetes are overweight or obese. Some people who are obese have gastric bypass surgery (GBS) to help them to lose weight.

Doctors investigated whether GBS affected sensitivity to insulin. They measured patients' sensitivity to insulin before and after GBS. About half of the patients had type II diabetes. The other half did not but were considered at high risk of developing the condition.

The table below shows the doctors' results. The higher the number, the greater the sensitivity to insulin.

Patients	**Mean sensitivity to insulin / arbitrary units (± SD)**	
	Before gastric bypass surgery	**1 month after gastric bypass surgery**
Did not have diabetes	0.55 (± 0.32)	1.30 (± 0.88)
Had type II diabetes	0.40 (± 0.24)	1.10 (± 0.87)

(b) The doctors concluded that many of the patients who did not have type II diabetes were at high risk of developing the condition.

Use the data in the table to suggest why they reached this conclusion.

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(c) The doctors also concluded that GBS cured many patients' diabetes but that some were not helped very much. Do these data support this conclusion? Give reasons for your answer.

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(Total 7 marks)

[7]