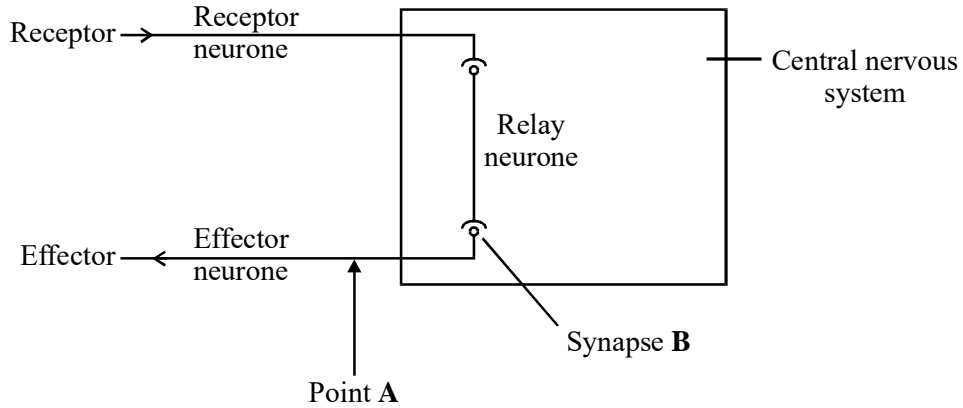


- I.** *Answers should be written in continuous prose. Credit will be given for biological accuracy, the organisation and presentation of the information and the way in which the answer is expressed.*

The diagram represents a reflex arc.



- (a) Describe and explain the events which occur in the effector neurone at point **A** during the passage of a nerve impulse.

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(7)

- (b) Describe the events which allow transmission to take place across the synapse labelled **B**.

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(6)

- (c) Reflexes are described as being rapid, automatic responses. Use the information in the diagram to explain those features of a reflex arc which result in the response being rapid and automatic.

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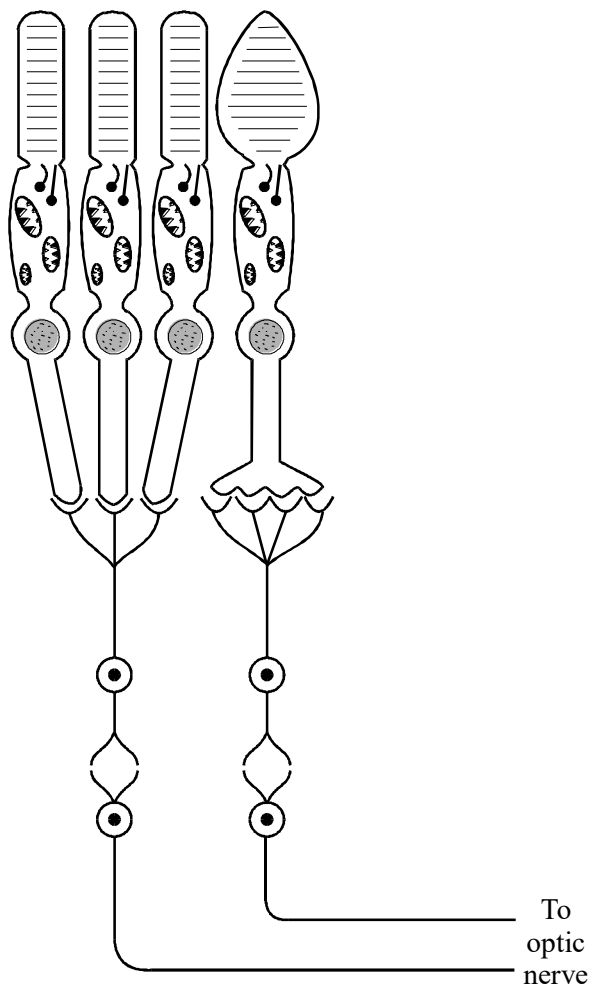
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(4)
(Total 17 marks)

2. The diagram shows the distribution of rods and cones in the retina of a human eye.



(a) Using information in the diagram, explain how:

(i) rod cells enable us to see in conditions of low light intensity;

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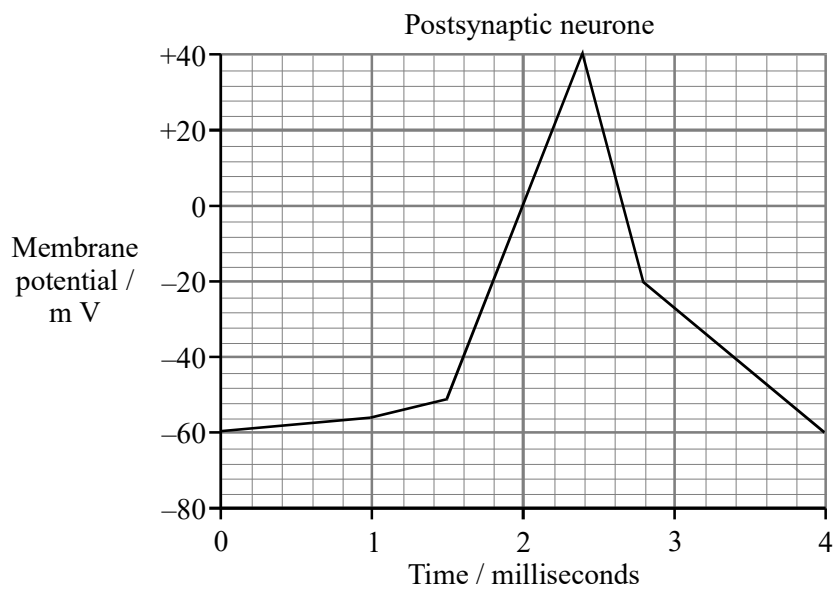
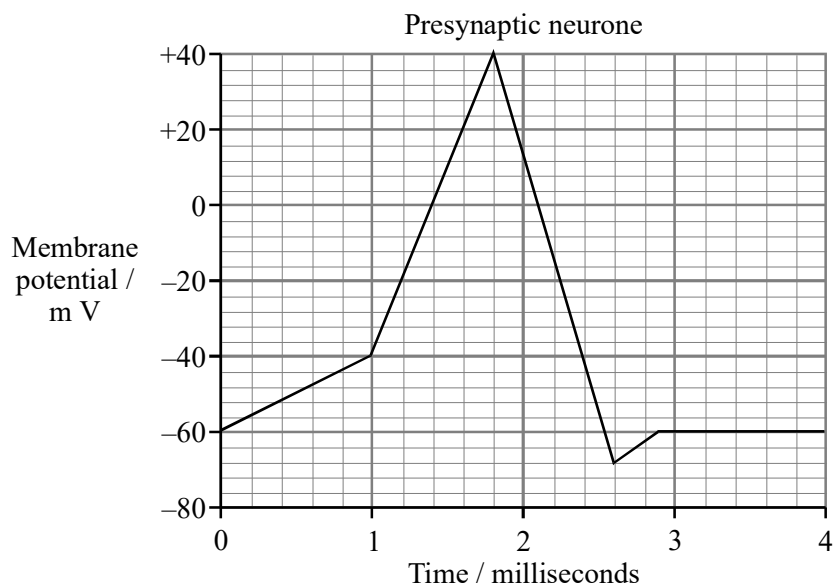
(2)

(ii) cone cells enable us to distinguish between objects close together.

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(2)

- (b) The graphs show the changes in membrane potential in a presynaptic neurone and a postsynaptic neurone when an impulse passes across a synapse.



- (i) What is the resting potential of the presynaptic neurone?

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(1)

(ii) Explain what causes the change in the membrane potential in the presynaptic neurone between 1 and 1.8 milliseconds.

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(3)

(iii) How long is the delay between the maximum depolarisation in the presynaptic and the maximum depolarisation in the postsynaptic membrane?

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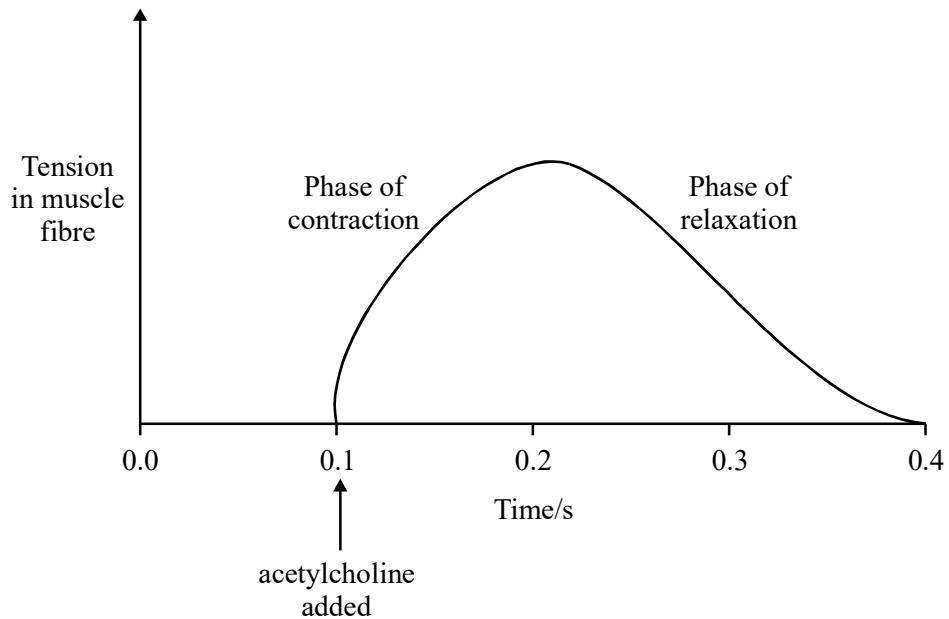
(1)

(iv) Describe the events that occur at the synapse during this delay.

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(3)

- (c) The point at which an individual neurone makes contact with a striated muscle fibre is called a neuromuscular junction. Acetylcholine solution was added to a neuromuscular junction. The graph shows the effect of the acetylcholine on the length of the muscle fibre.



Acetylcholine is normally hydrolysed by an enzyme at the neuromuscular junction. Some insecticides inhibit this enzyme. Suggest how these insecticides are effective in killing insects.

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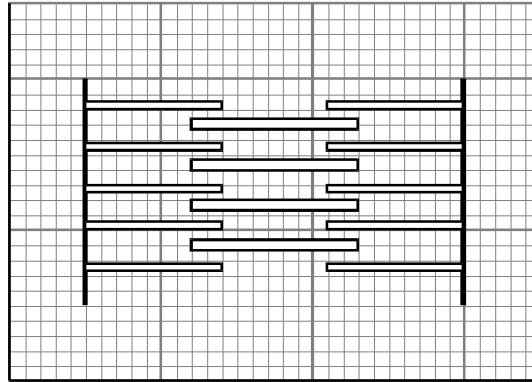
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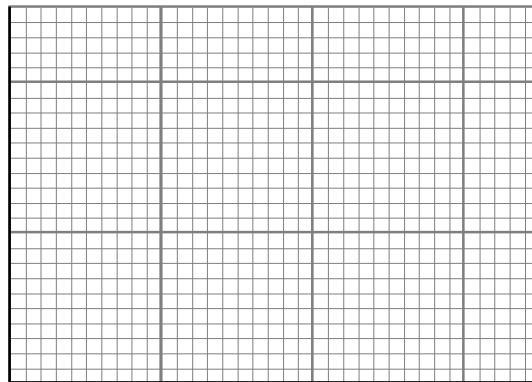
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(3)

- (d) The diagram shows the positions of the muscle proteins, actin and myosin, in a non-contracted sarcomere.



Using the same scale as in the diagram, draw on the grid below, a sarcomere after contraction.



(1)

- (e) Explain the role of the following during muscle contraction.

- (i) Calcium ions

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(2)

(ii) Mitochondria

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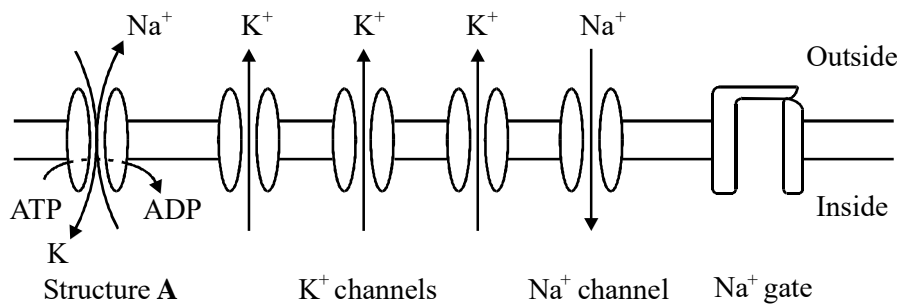
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(2)
(Total 20 marks)

3. The diagram shows some of the pump and channel proteins in the cell surface membrane of a neurone.



(a) (i) What evidence is there in the diagram that structure A is involved in active transport?

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(1)

(ii) Explain the role of the Na⁺ and K⁺ channels in producing the membrane resting potential.

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(2)

- (b) Explain how structure **A** and the Na^+ gate allow depolarisation of this membrane.

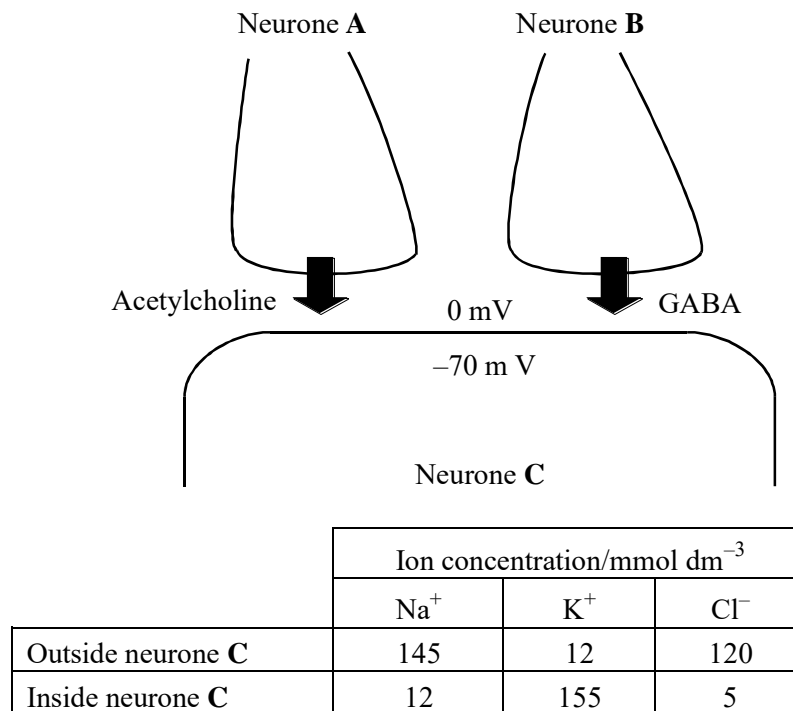
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(2)
(Total 5 marks)

4. The diagram shows dendrites from each of two neurones, **A** and **B**, forming synapses with a third neurone, **C**. Concentrations of some ions are also shown.



- (a) Acetylcholine increases the permeability of the postsynaptic membrane to Na^+ ions. Explain how acetylcholine released from neurone **A** generates an action potential in neurone **C**.

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(3)

- (b) Neurone **B** releases a substance called GABA as its neurotransmitter. GABA increases the permeability of the postsynaptic membrane to Cl^- ions. Suggest how impulses in neurone **B** would reduce the chances of an action potential in neurone **C**.

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(2)

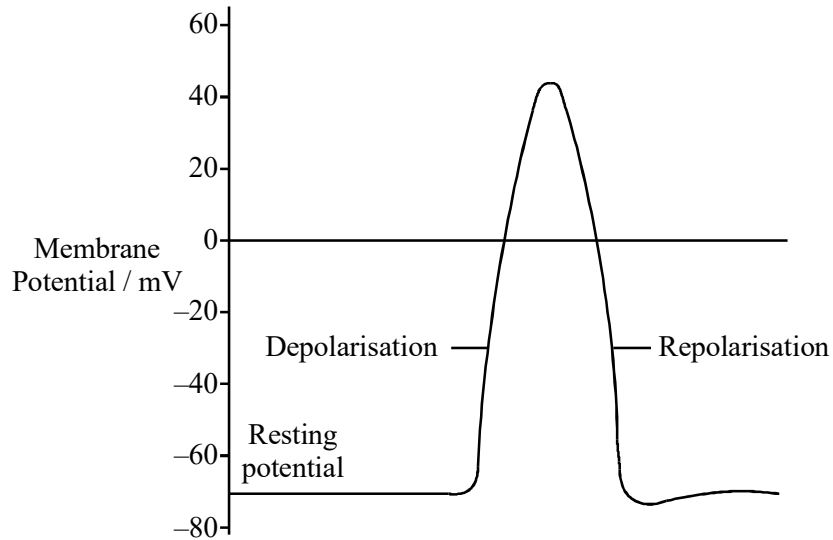
- (c) Suggest a benefit of neurone **C** synapsing with the two types of neurone, **A** and **B**.

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(1)

(Total 6 marks)

5. (a) The diagram shows the changes in the membrane potential at one point on an axon when an action potential is generated.



- (i) Explain how

A the resting potential of -70 mV is maintained;

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(3)

B depolarisation takes place.

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(1)

(ii) Explain why another action potential cannot be generated during repolarisation.

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(2)

S (b) (i) Explain why a neurotransmitter (e.g. acetylcholine) can only bind with one type of receptor protein in the postsynaptic membrane.

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(2)

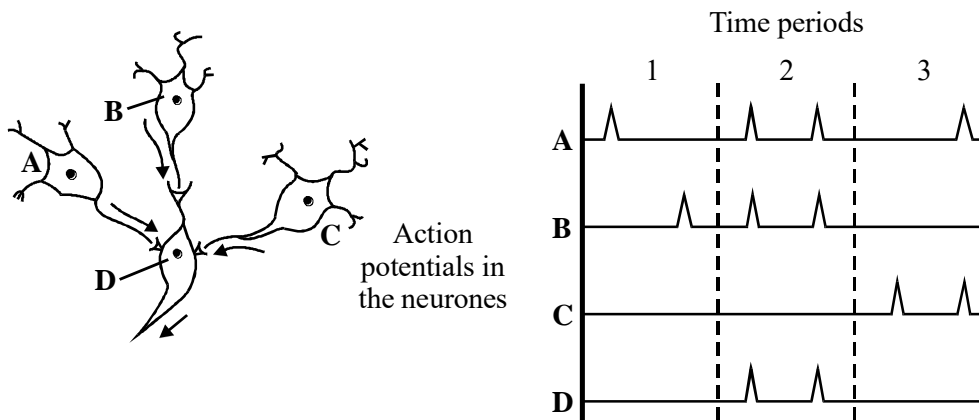
(ii) What is the role of calcium ions (Ca^{2+}) in synaptic transmission?

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(1)

(c) The diagram shows part of a nerve network. The graphs show action potentials in neurones **A**, **B** and **C** and those which result in neurone **D**.



- (i) In terms of summation, explain why an action potential is generated in neurone **D** in time period 2.

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(2)

- (ii) Explain why no action potential is generated in neurone **D** during time period 1.

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(2)

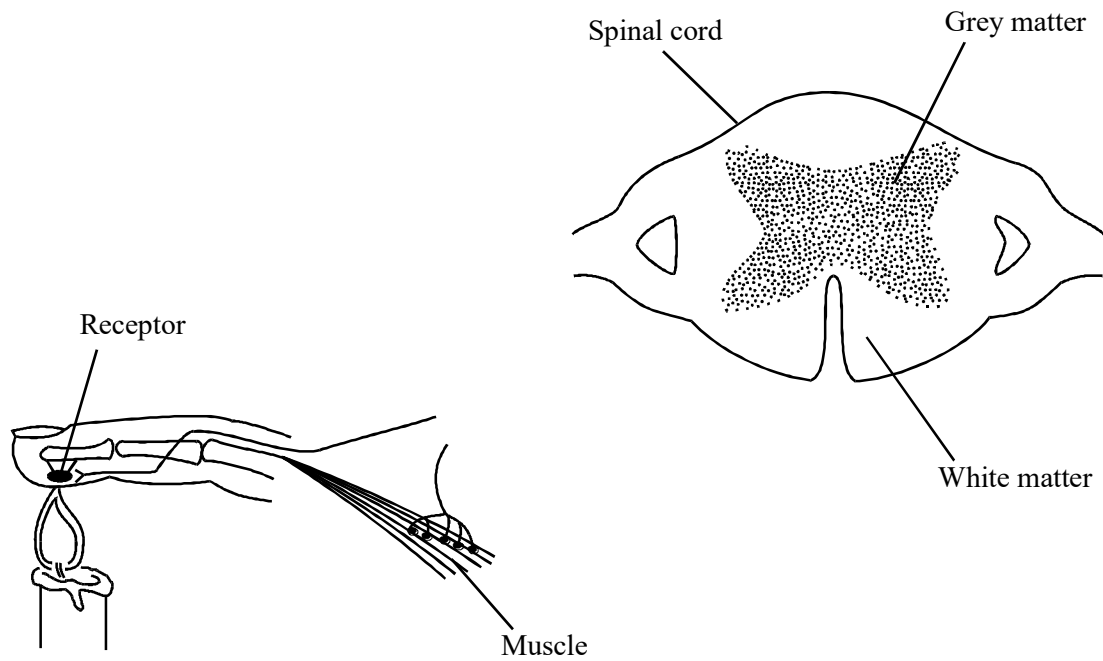
- (iii) From the results in time period 3, deduce the nature of the synapse between neurones **C** and **D**. Explain your answer.

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(2)

(Total 15 marks)

6. The diagram shows part of a simple reflex arc containing three neurones.



(a) Complete the diagram by drawing and labelling the structures that conduct impulses into, through, and out of the spinal cord.

(3)

(b) Explain how synapses ensure that a nerve impulse is transmitted in only one direction.

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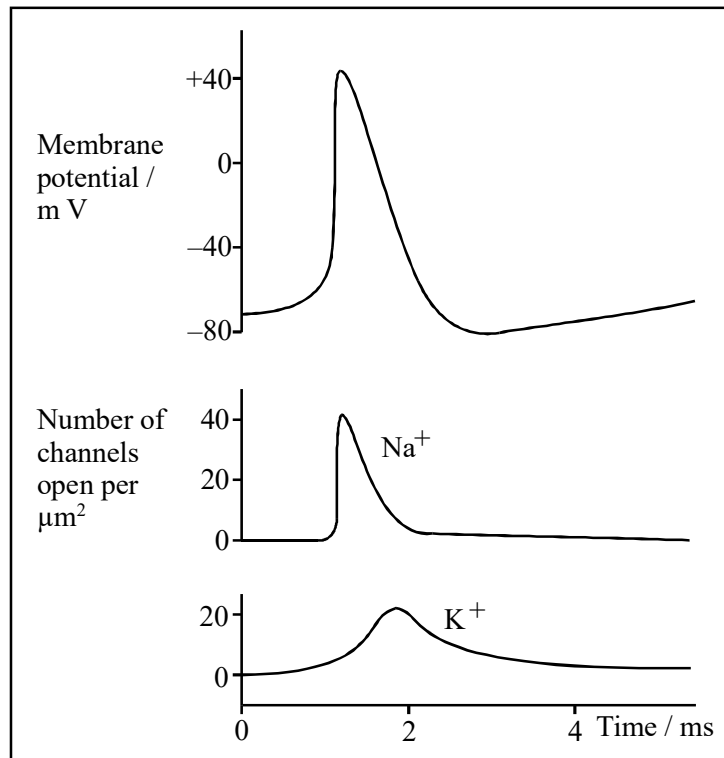
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(2)
(Total 5 marks)

7. (a) The graphs in **Figure 1** show the relationship between the membrane potential of an axon membrane and the numbers of Na^+ (sodium ion) channels and K^+ (potassium ion) channels that are open.



Using the information in the graphs, explain how

- (i) the action potential is generated;

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(2)

(ii) the axon membrane is repolarised.

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(2)

(b) The secretion of gastric juice by the stomach is stimulated by nerves and by hormones. **Figure 2** shows the volume of gastric juice secreted following nervous stimulation and hormonal stimulation.

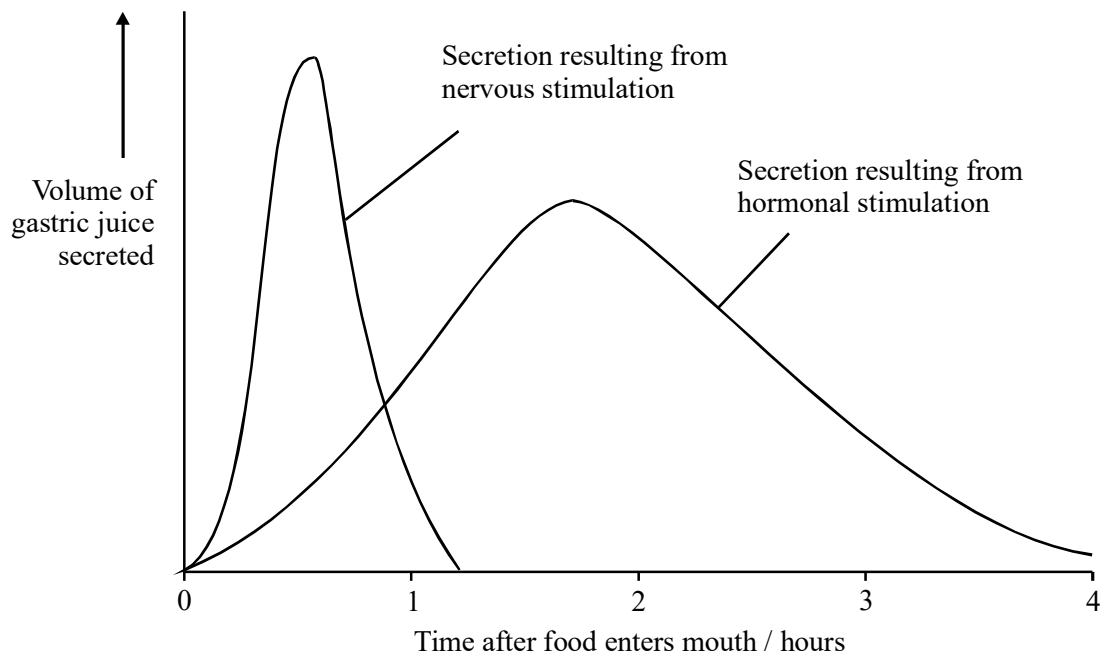


Figure 2

Give **two** differences between the nervous and hormonal control of the secretion of gastric juice. Use information in the graph to illustrate your answer.

1

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2

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(2)

(c) Gastric juice contains pepsin.

(i) Pepsin is produced as inactive pepsinogen. What is the advantage of this?

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(2)

(ii) Pepsin is an endopeptidase. What is an *endopeptidase*?

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(1)

(iii) What is the advantage in endopeptidases acting on proteins before exopeptidases do?

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(2)

S (d) When pepsin leaves the stomach it enters the small intestine. Explain how pepsin is inactivated by the high pH in the small intestine.

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(4)
(Total 15 marks)

8. (a) When pressure is applied to a Pacinian corpuscle, an impulse is produced in its sensory neurone. Explain how.

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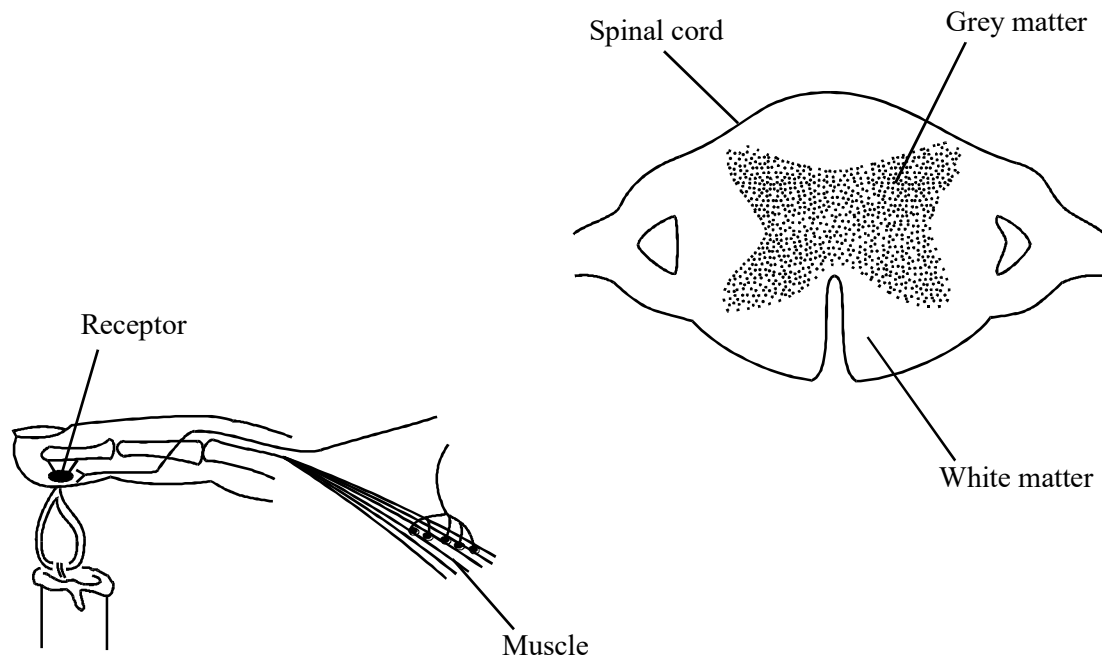
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(2)

- (b) The diagram shows part of a simple reflex arc containing three neurones.



Complete the diagram by drawing in and labelling the structures that conduct impulses into, through, and out of the spinal cord.

(3)
(Total 5 marks)

9. (a) **Figure 1** shows part of a nerve cell. The numbers show the membrane potential, in millivolts, at various points along the axon.

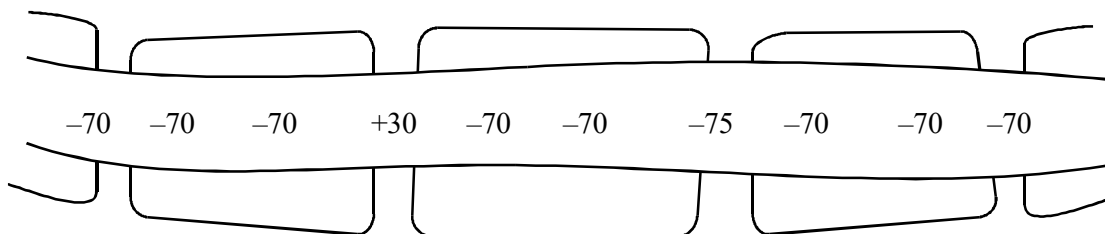


Figure 1

- (i) Draw a circle on **Figure 1** to show the region of axon membrane most permeable to potassium ions. Explain your answer.

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(2)

- (ii) Draw an arrow on **Figure 1** to indicate the direction in which the nerve impulse is being conducted. Explain your answer.

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(2)

- S** (b) The rate of oxygen consumption of a neurone increases when it conducts a high frequency of impulses. Explain why.

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(4)

(c) **Figure 2** shows the positions of two electrodes on the arm of a 20-year-old volunteer.

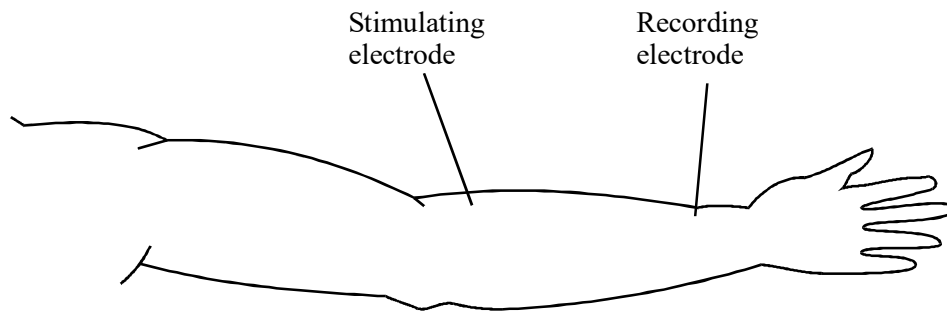


Figure 2

The first electrode was used to stimulate motor neurones in the ulnar nerve at different positions along the arm. Impulses were produced in motor neurones as a result of the stimulation and travelled along the arm, producing contraction in a muscle near the wrist. As the muscle started to contract, it produced electrical impulses which were recorded by the second electrode. The time delay between the stimulation of the nerve and the start of the muscle contraction was recorded. The results of this investigation have been plotted on **Figure 3**.

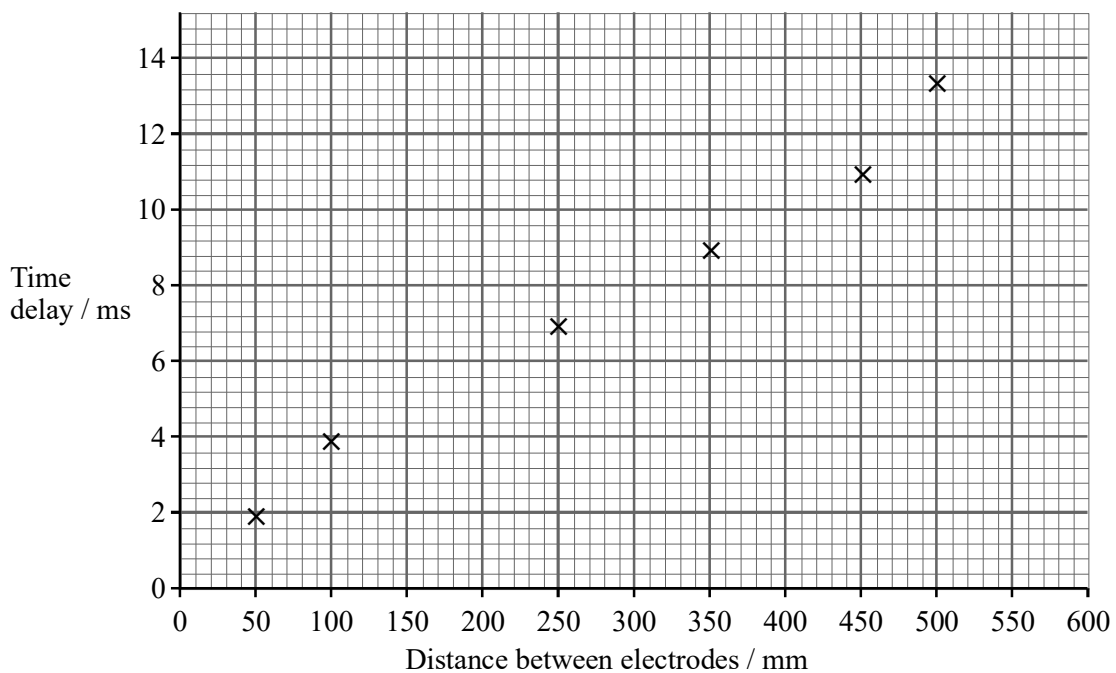


Figure 3

Draw a line of best fit on **Figure 3**. Use this line to calculate the speed of an impulse along the motor neurones in the ulnar nerve of this volunteer. Show your working.

Answer

(3)

(Total 11 marks)

10. **Figure 1** shows two motor neurones, **A** and **B**. It also shows the synapses of neurone **B** with three other neurones, **P**, **Q** and **R**.

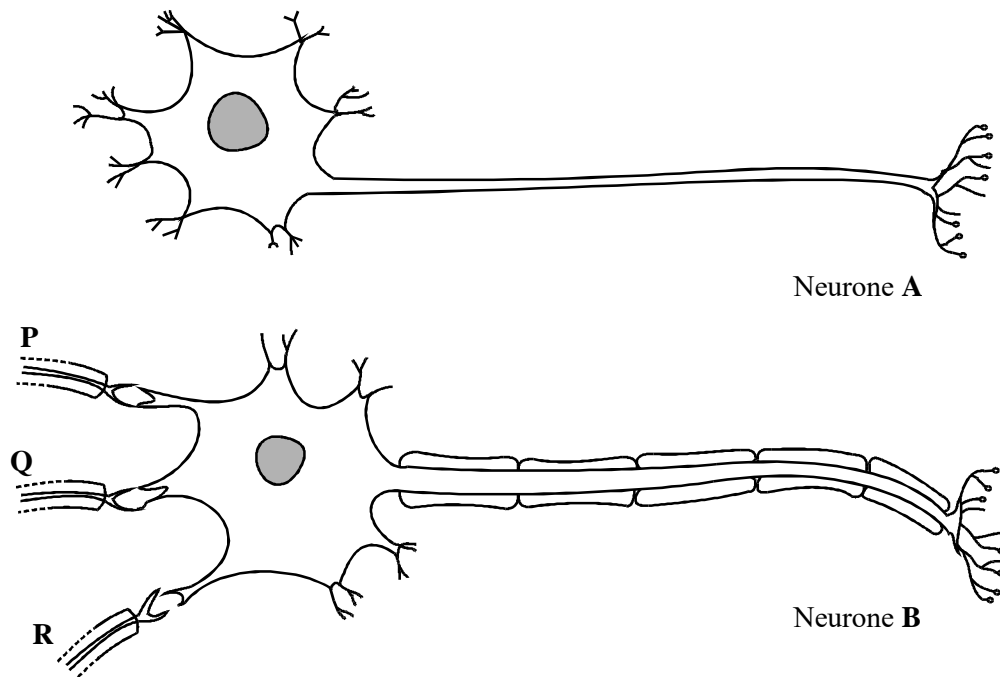


Figure 1

- (a) (i) An action potential is produced in neurone **A**. Describe how this action potential passes along the neurone.

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(3)

- S** (ii) Explain why the transmission of a series of nerve impulses along neurone **B** uses less energy than transmission along neurone **A**.

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(3)

- (b) Neurones of type **A** are found in the autonomic nervous system. The autonomic nervous system consists of the sympathetic division and the parasympathetic division.

- (i) Suggest the effect that stimulation by neurones of the sympathetic division would have on the diameter of arterioles leading to skeletal muscle. Explain your answer.

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(2)

- S (ii) Explain the effect of the parasympathetic division of the autonomic nervous system on cardiac output.

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(4)

- (c) (i) **Figure 2** shows the effect of impulses from neurones **P** and **Q** on the production of an action potential in neurone **B**.

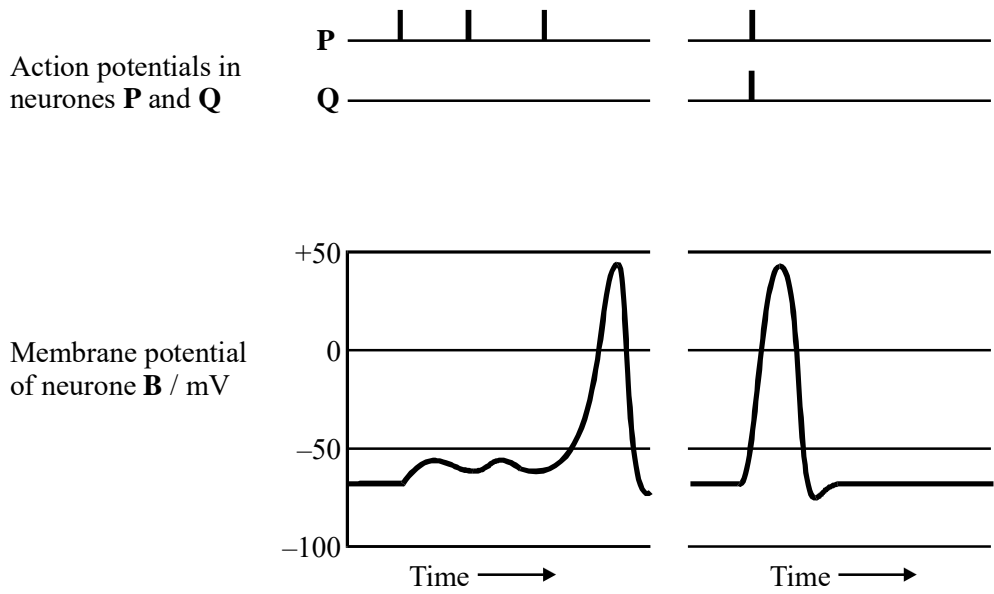


Figure 2

Each effect is a type of summation. Use information in **Figure 2** to explain the two types.

First type

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Second type

.....

(2)

(ii) **Figure 3** shows the effect of an impulse from neurone **R** on the membrane potential of neurone **B**.

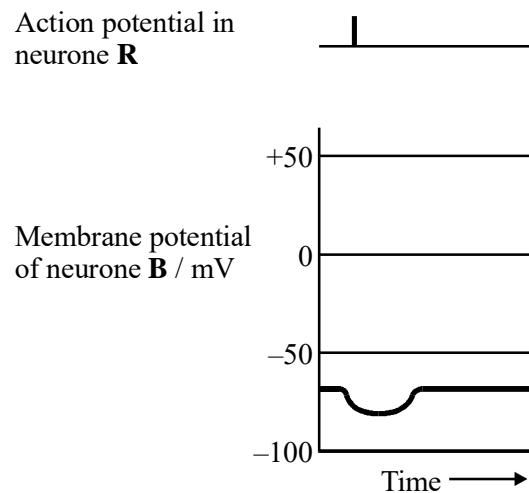


Figure 3

Describe the kind of synapse between neurone **R** and neurone **B**.

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(1)

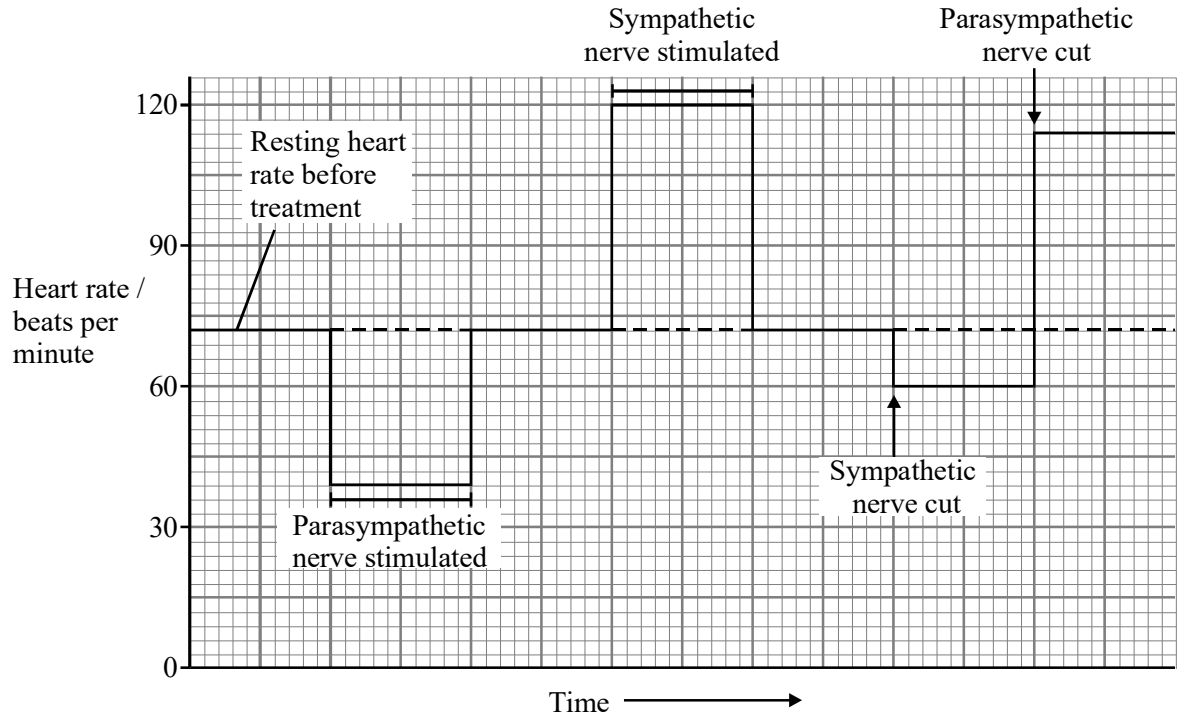
(Total 15 marks)

11. (a) Name the transmitter released from the postganglionic motor neurones of the sympathetic division of the autonomic nervous system.

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(1)

- (b) The graph shows the results of a sequence of treatments to investigate the control of heart rate by the autonomic nervous system.



- (i) Explain what the results of cutting the sympathetic and parasympathetic nerves demonstrate about the control of resting heart rate.

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(ii) What does the graph suggest about how a change in heart rate occurs when a person exercises?

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(1)
(Total 5 marks)

12. (a) Describe the events that take place in a neurone which produce an action potential.

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(6)

(b) Describe how transmission occurs across a synapse.

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(4)

S (c) Explain what is meant by the tertiary structure of a protein and describe the importance of this in transmission across a synapse.

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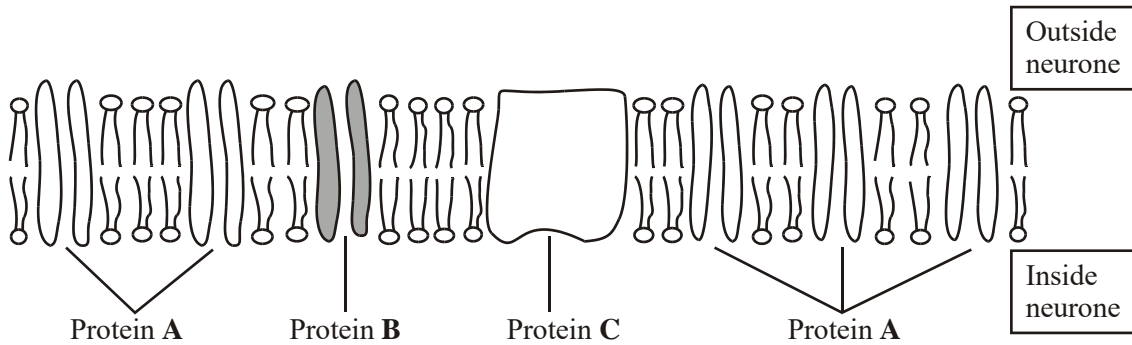
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(5)

(Total 15 marks)

13. The resting potential of a neurone is maintained by the unequal distribution of ions inside and outside the plasma membrane. The diagram shows the plasma membrane of a neurone and the three different proteins that are involved in maintaining the resting potential.



- (a) Protein C requires ATP to function. Describe the role of protein C.

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(2)

- S (b) (i) Proteins A and B differ from each other. Explain why different proteins are required for the diffusion of different ions through the membrane.

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(2)

- (ii) The plasma membrane of the neurone is more permeable to potassium ions than to sodium ions. Give the evidence from the diagram that supports this observation.

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(1)
(Total 5 marks)

14. Secretion of neurotransmitters into a synaptic cleft may produce an action potential in a postsynaptic neurone.

- (i) Explain how the release of acetylcholine at an excitatory synapse reduces the membrane potential of the postsynaptic membrane.

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(2)

- (ii) Explain what causes transmission at a synapse to occur in only one direction.

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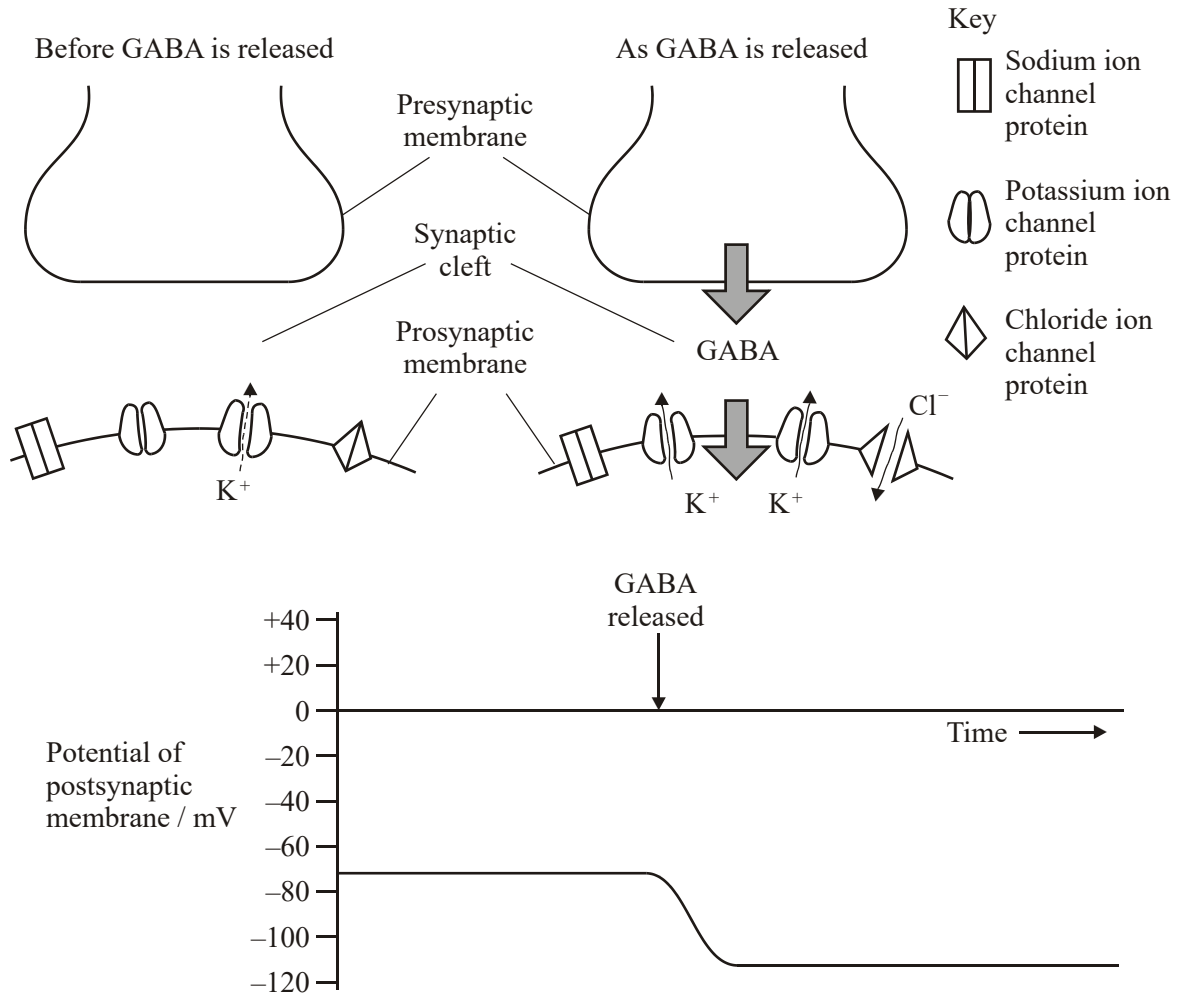
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(2)

- (iii) GABA is a neurotransmitter which inhibits the production of action potentials. The diagram and the graph show how the release of GABA from a presynaptic membrane affects the membrane potential of a postsynaptic membrane.



When the postsynaptic membrane is stimulated by acetylcholine, an action potential is less likely if GABA is released at the same time. Explain why.

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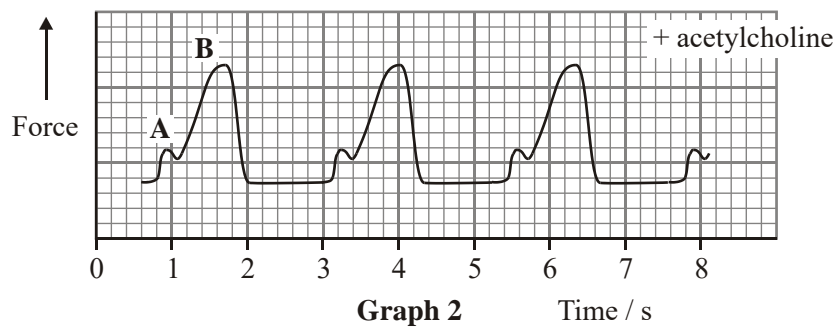
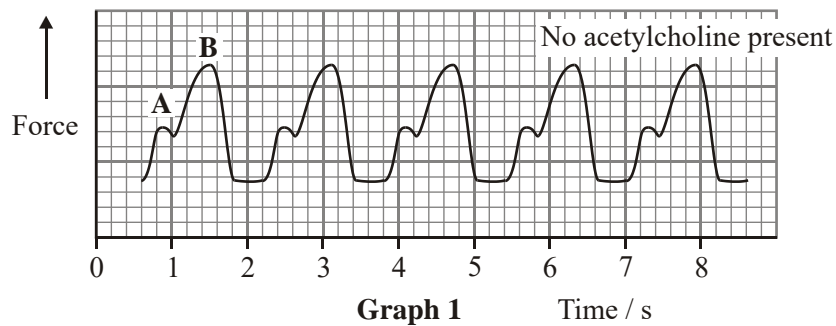
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(4)

(Total 8 marks)

15. 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.



- (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

.....

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;
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?

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(1)

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

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(4)

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

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(3)

(Total 15 marks)

16. Write an essay on the following topic. You should select and use information from different parts of the specification. Credit will be given not only for the biological content, but also for the selection and use of relevant information, and for the organisation and presentation of the essay.

Negative feedback and its importance in biology.

(Total 25 marks)

17. (a) The table shows the membrane potential of an axon at rest and during the different phases of an action potential. Complete the table by writing in each box whether the sodium ion (Na^+) channels and potassium ion (K^+) channels are open or closed.

| | Resting | Starting to depolarise | Repolarising |
|---|---------|------------------------|--------------|
| Membrane potential/mV | -70 | -50 | -20 |
| Na^+ channels in axon membrane | | | |
| K^+ channels in axon membrane | | | |

(2)

- (b) Describe how the resting potential is established in an axon by the movement of ions across the membrane.

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(2)

- S (c) Sodium and potassium ions can only cross the axon membrane through proteins.
Explain why.

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(2)

(Total 6 marks)

18. Write an essay on the following topic. You should select and use information from different parts of the specification. Credit will be given for the biological content. It will also be given for the selection and use of relevant information, and for the organisation and presentation of the essay.

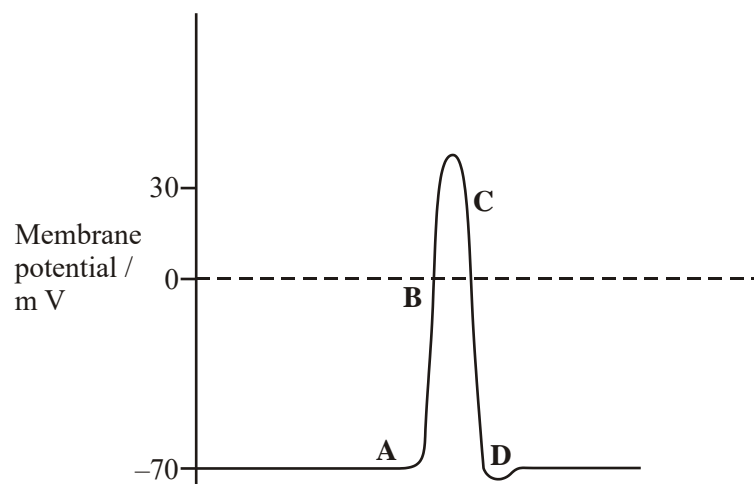
Inorganic ions include those of sodium, phosphorus and hydrogen.

Describe how these and other inorganic ions are used in living organisms.

(Total 25 marks)

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

Figure 1



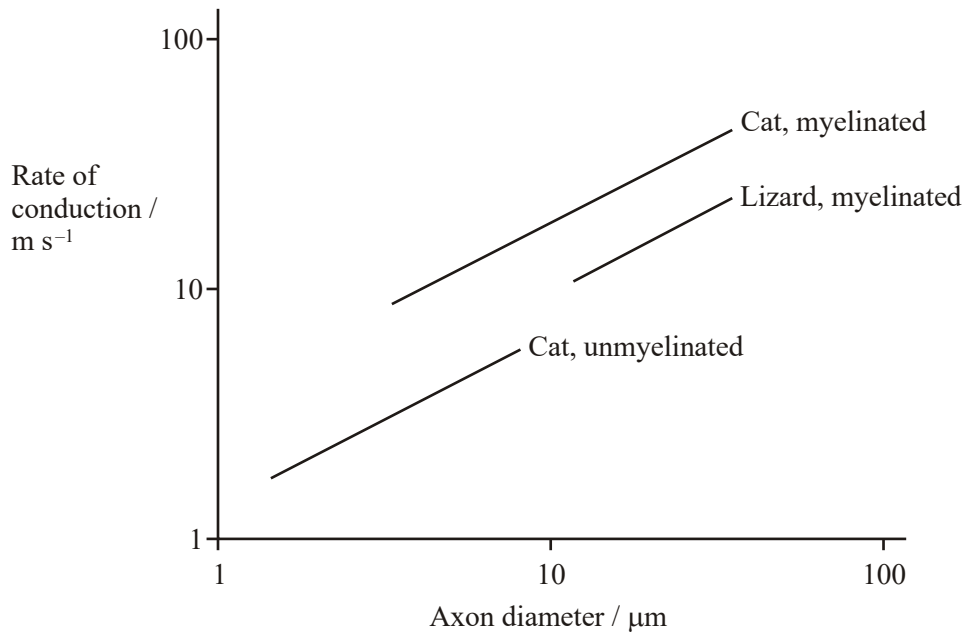
The changes shown in **Figure 1** are due to the movement of ions across the axon membrane. Complete the table by giving the letter (**A** to **D**) that shows where each process is occurring most rapidly.

| 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)

- S** (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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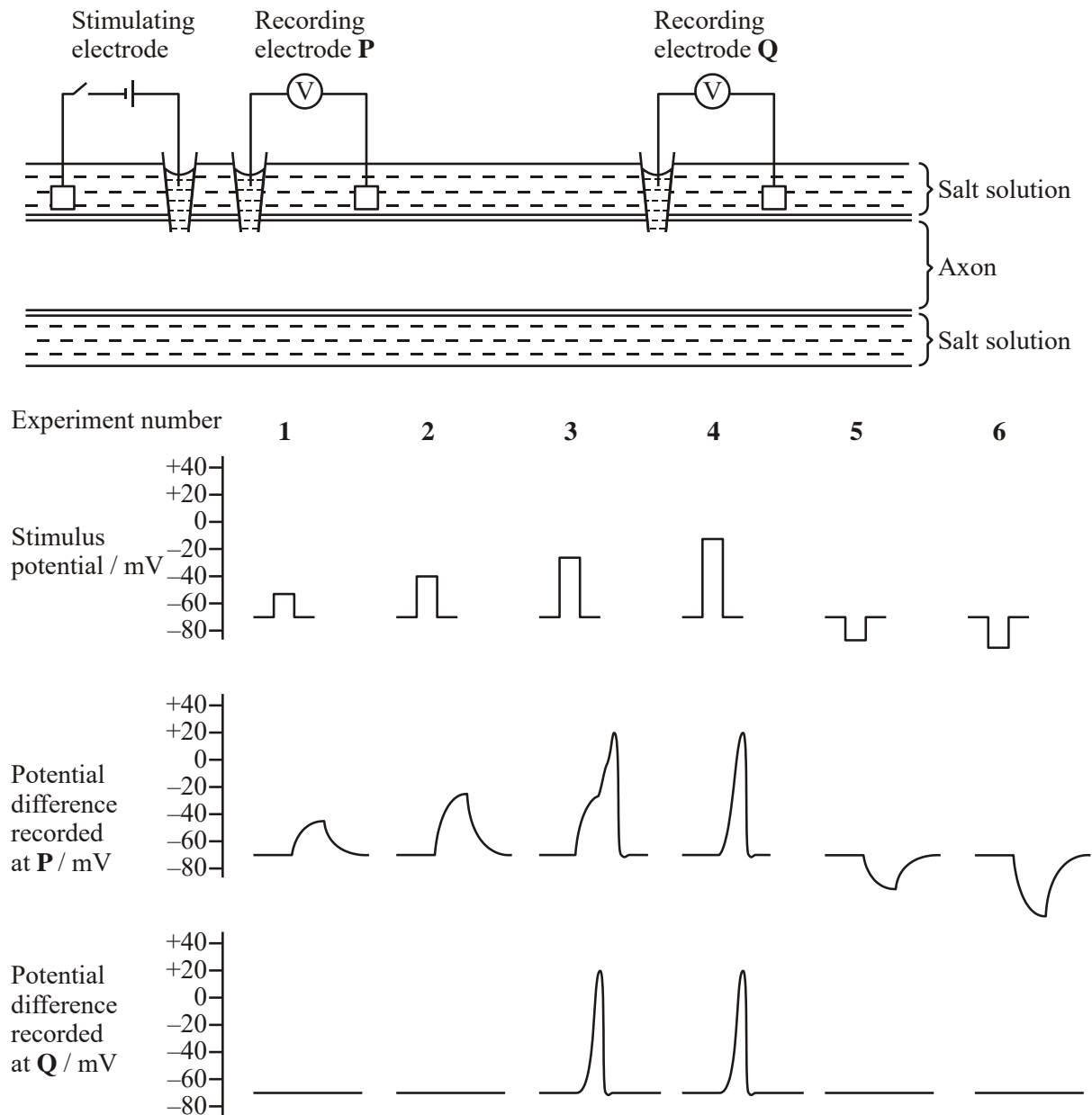
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(2)

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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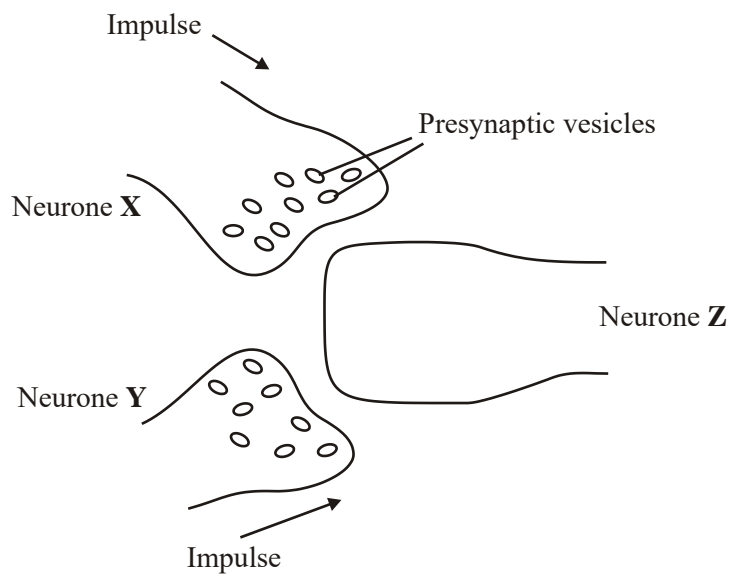
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(5)

- (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 5**, to explain how neurones **X** and **Y** have an antagonistic effect on neurone **Z**.

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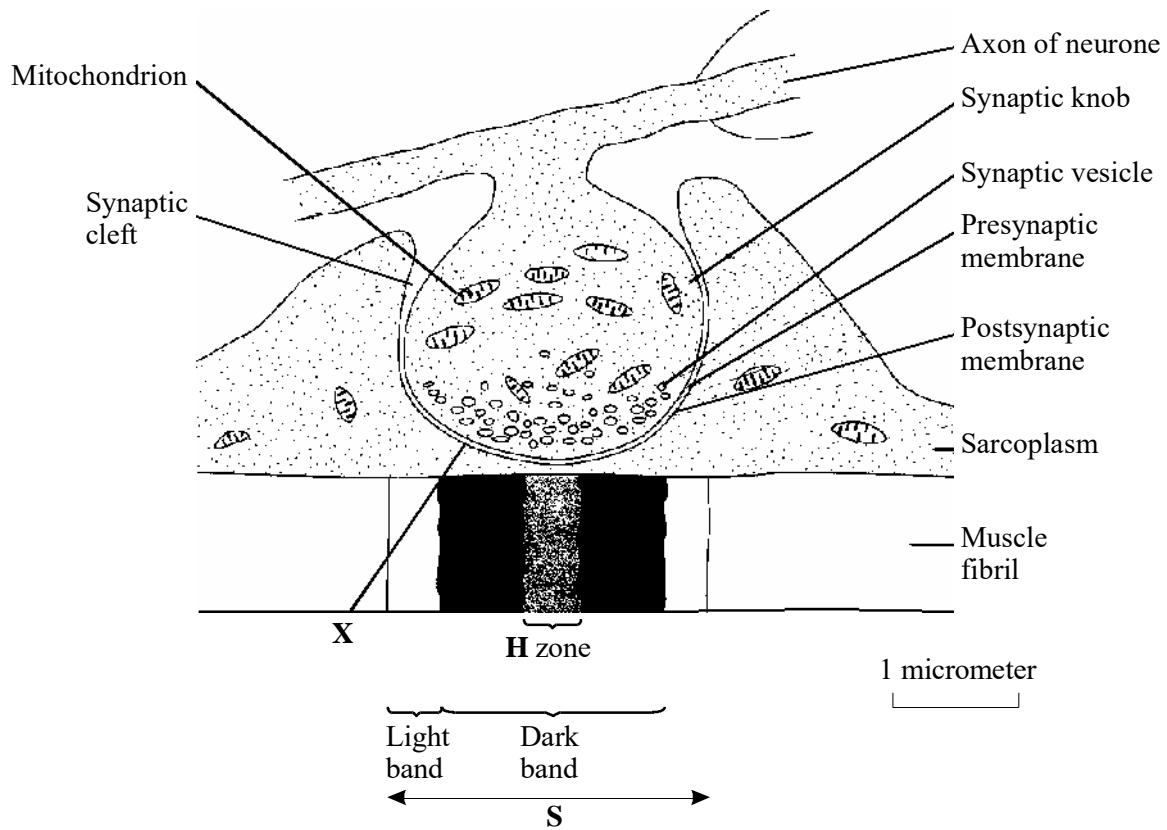
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(4)
(Total 15 marks)

20. The diagram shows a neuromuscular junction.



(a) (i) Name the neurotransmitter that is released from the synaptic knob.

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(1)

(ii) By what process does this neurotransmitter cross the synaptic cleft?

.....

(1)

(iii) Calculate the width of the synaptic cleft at **X**. Show your working.

Answer.....

(2)

(b) Suggest **two** functions of the energy released by the mitochondria in the synaptic knob.

1.
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2.
.....

(2)

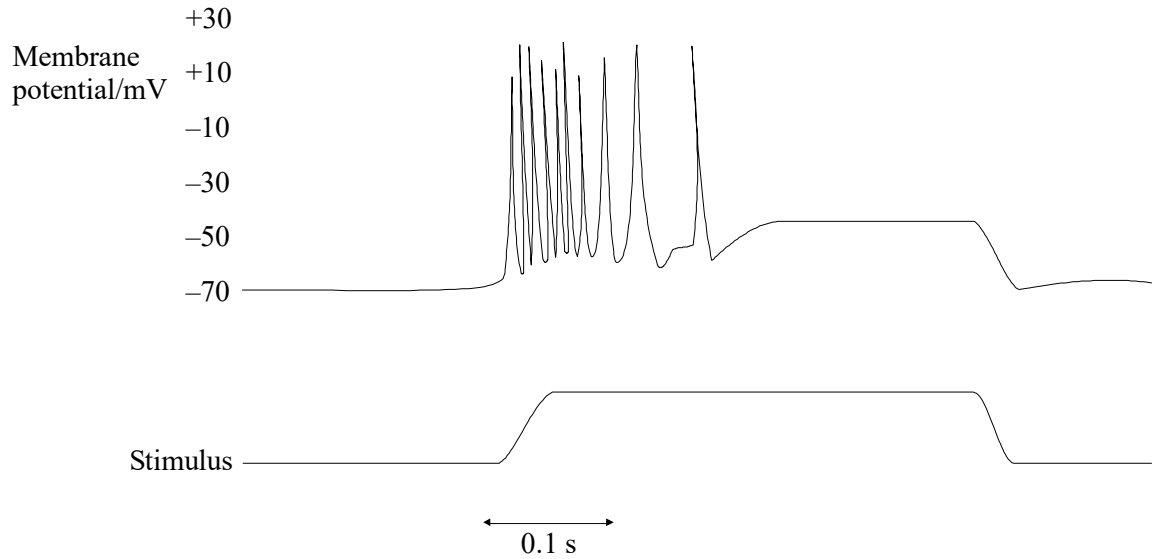
(c) Describe how the appearance of the section of the muscle fibril labelled **S** would change when the fibril is stimulated by the neurotransmitter.

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(2)

(Total 8 marks)

21. The membrane potential of a neurone leading from a stretch receptor in a muscle was measured before, during and after a period in which the muscle was stretched. The results are shown in the graph.



- (a) Explain what causes the initial increase in membrane potential.

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(2)

- (b) How do these results illustrate the ‘all-or-nothing’ principle?

.....

(1)

- (c) (i) For how long was the muscle stretched?

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(1)

- (ii) Describe and explain the effect on the neurone of keeping the muscle stretched for this period.

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(2)

- (iii) Suggest **one** biological advantage of this effect on the neurone.

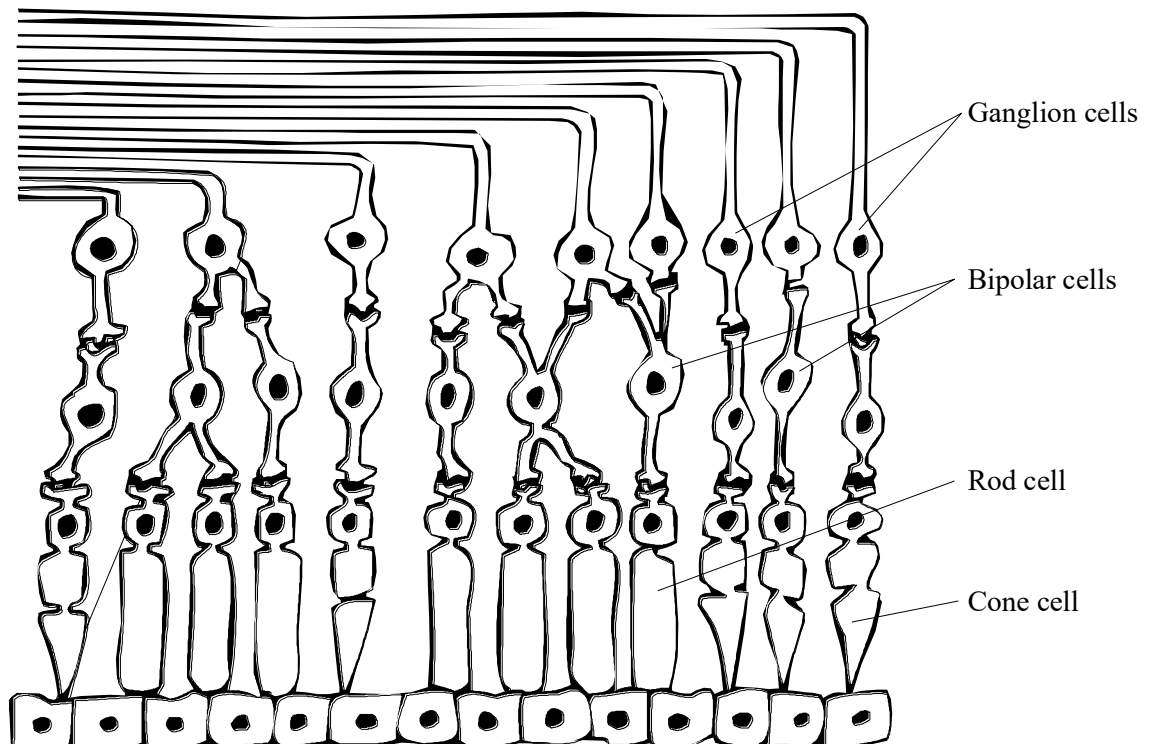
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(1)

(Total 7 marks)

22. The diagram shows the structure of the retina.



Use the diagram to help you to explain how the structure of the retina and its neuronal connections enable a person to have

- (i) a high degree of visual sensitivity in low light levels;

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- (ii) a high degree of visual acuity.

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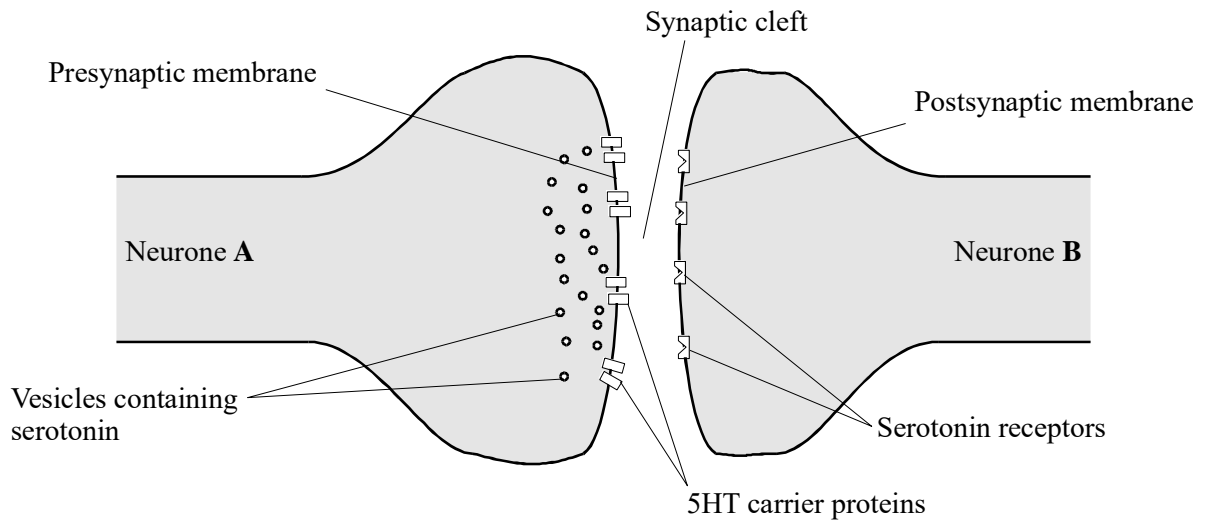
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(Total 6 marks)

23. Serotonin is a neurotransmitter which is produced by certain neurones in the brain. One of its effects is to increase the activity of sensory neurones in the brain. It also usually improves a person's mood and keeps the person awake. The diagram shows a synapse at which serotonin is the neurotransmitter.



- (a) Explain how the release of the neurotransmitter, serotonin, by neurone A would initiate an impulse in neurone B.

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(3)

- (b) The serotonin is normally rapidly reabsorbed from the synaptic cleft by 5HT carrier proteins in the presynaptic membrane. Suggest **one** advantage of rapidly reabsorbing the serotonin.

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(1)

(c) The active ingredient in the drug, Ecstasy, is MDMA. MDMA blocks the attachment of serotonin molecules to the 5HT carrier proteins.

(i) Suggest how MDMA may temporarily improve a person's mood.

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(2)

(ii) MDMA may cause long-term damage to the 5HT carrier proteins. This leads to a depressed mood. Suggest why.

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(1)

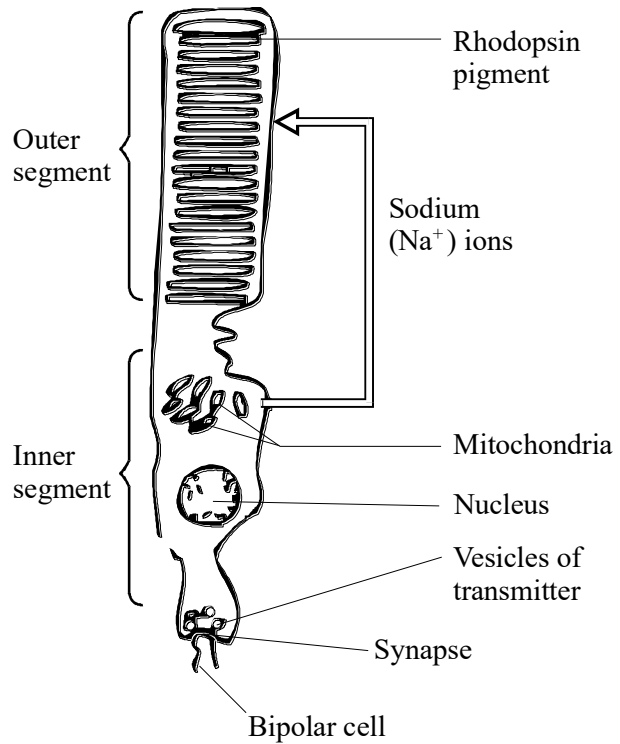
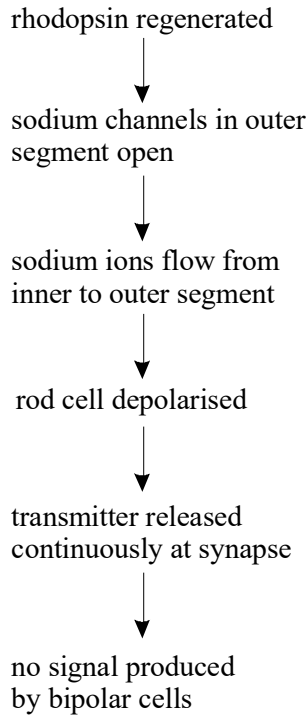
(Total 7 marks)

24. (a) In the retina of a human eye there are about 125 million rod cells but only about 7 million cone cells. Give **two** reasons why, despite this difference, colour vision is much better for seeing detail.

1.....
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2.....
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(2)

- (b) The flow chart shows some of the events that occur in a rod cell in the dark, and the diagram shows the flow of sodium ions in a rod cell in the dark.



Rod cells differ from other receptors in that they are depolarised when they are not being stimulated.

- (i) Explain what is meant by depolarisation.

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(ii) Suggest why rod cells require a large number of mitochondria.

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(2)

(iii) A bipolar cell generates a signal to the brain when the amount of transmitter reaching it from a rod cell falls. When illuminated the rhodopsin molecules change shape. This produces a series of reactions that cause the sodium channels in the outer segment to close.

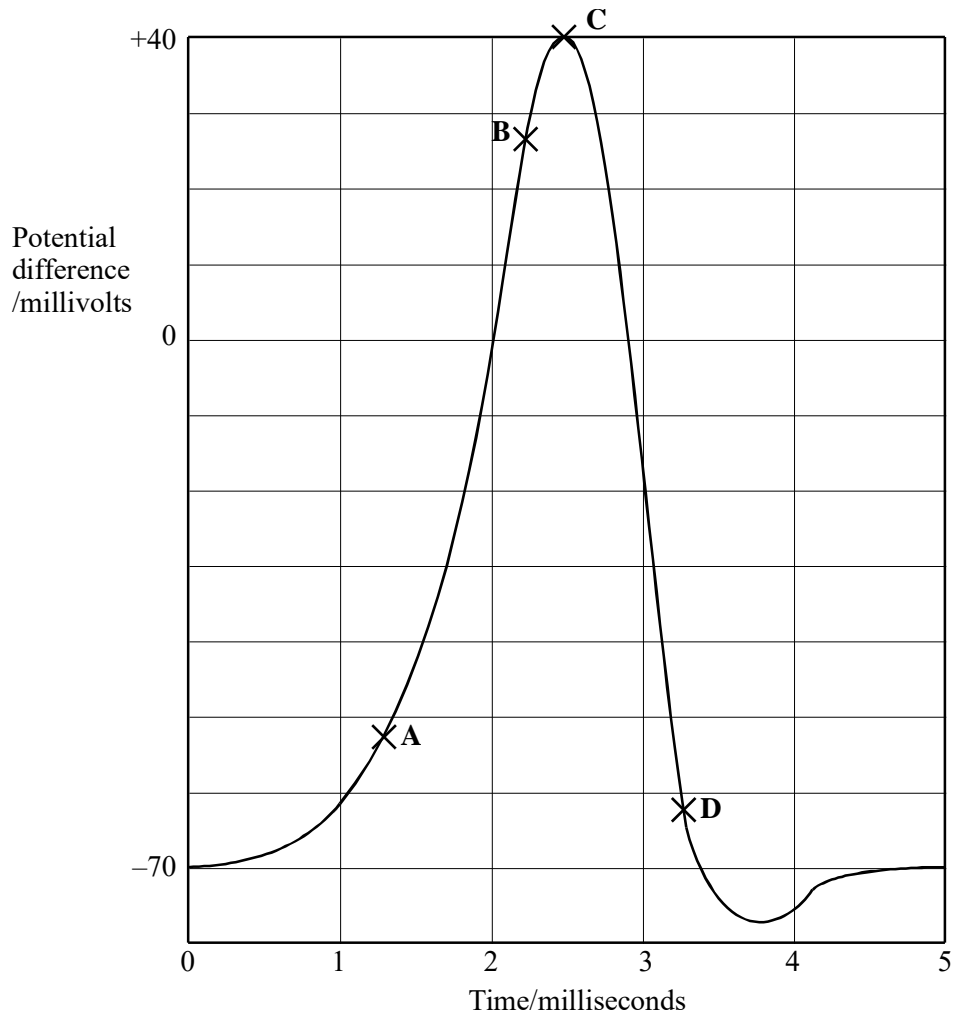
Explain how illumination will result in the generation of a signal by a bipolar cell.

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(2)

(Total 8 marks)

25. The diagram shows a typical action potential in a neurone.



- (a) Explain how the movement of ions brings about the changes in potential difference occurring between points **A** and **B**, and between points **C** and **D**.

A-B.....

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C-D.....

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(b) Describe the process of transmission across a neuromuscular junction.

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(7)

(c) Explain how transmission of information in the nervous system may be modified by summation.

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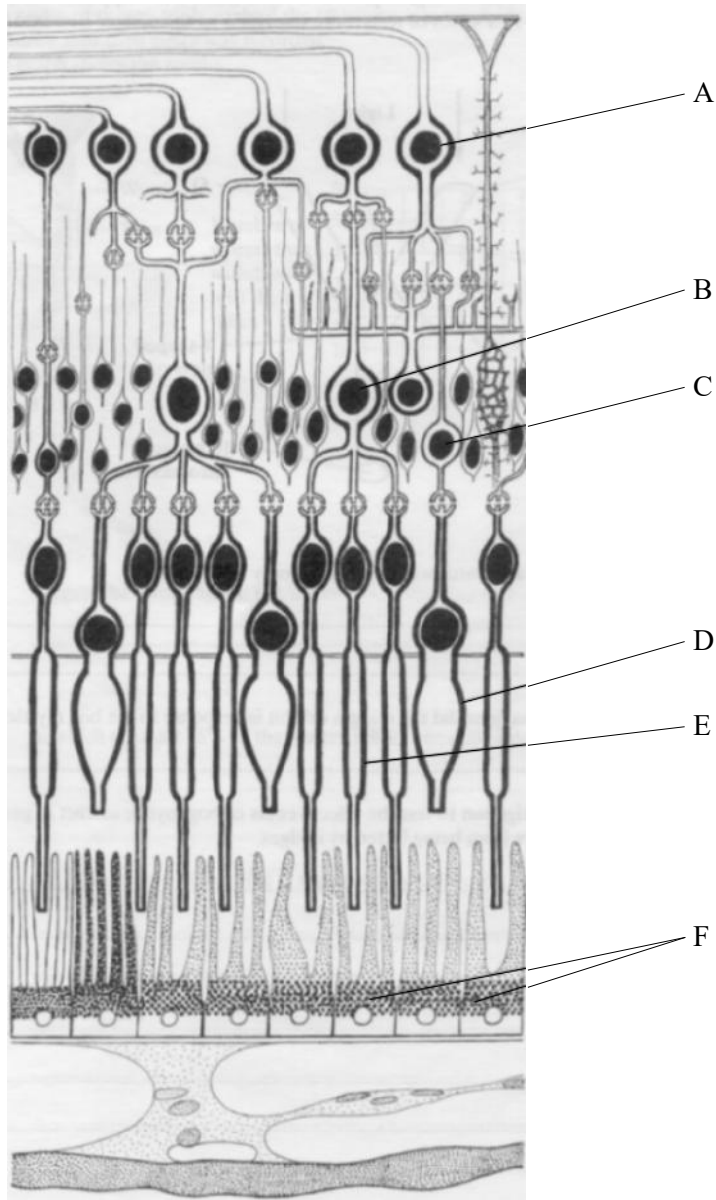
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(2)

(Total 12 marks)

26. The diagram shows a section through the retina of the human eye.



(From An Atlas of Histology. Beryl Freeman and Brian Bracegirdle. Reprinted by permission of Heinemann Educational Publishers.)

- (a) Name the type of cell labelled

D.....

E.....

- (b) The cell labelled **A** is incomplete. Where is the rest of this cell located?

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.....

(1)

- (c) The cells labelled **F** contain black pigment. Suggest the function of this pigment.

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(1)

- (d) The cells labelled **B** and **C** are connected to different numbers of receptor cells. Explain the advantage of the number of connections between cell types **B** and **E**.

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(2)

(Total 5 marks)

27. Read the following passage.

Cone snails extend a long, whippy tube tipped with a poisonous barb disguised as food. Fish that swallow the bait are instantly harpooned, their fate sealed by a dose of paralysing toxins squirted through the barb.

Research at Stanford University has shown that some of the toxins block the tiny channels that allow sodium ions through the membranes of the nerve and muscle cells. Other toxins paralyse fish by blocking the receptors for acetylcholine at neuromuscular junctions.

Cone snails produce many different toxins. These toxins are very small; they are protein fragments seldom longer than 30 amino acids or shorter than 10.

(a) Describe the structure of the channels that allow sodium ions through membranes.

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(2)

(b) Explain how each of the following leads to paralysis of fish.

(i) blocking of sodium channels in nerve cells

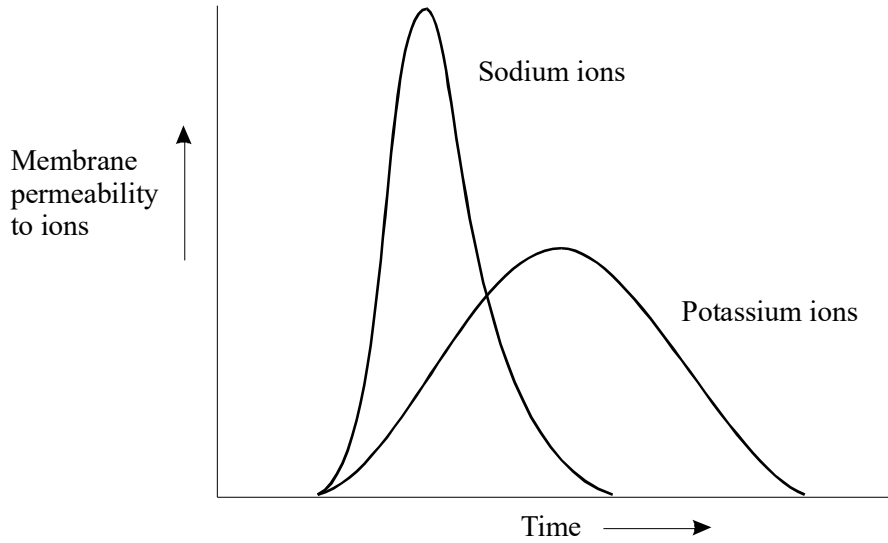
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(ii) blocking of receptors for acety choline in nerve cells

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(6)
(Total 8 marks)

28. The graph shows the changes in permeability of a neurone membrane to potassium (K^+) and sodium (Na^+) ions during the course of an action potential.



(a) During the course of an action potential, the potential difference across the neurone membrane changes from -70 to $+40$ and back to -70 mV. Use the information in the graph to explain what causes these changes.

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(4)

(b) (i) What is meant by the ‘all or nothing’ nature of a nerve impulse?

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(2)

- (ii) Neurones can respond to both strong and weak stimuli. Describe how a neurone conveys information about the strength of a stimulus.

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(1)

- (c) Describe what is meant by *temporal summation* at a synapse.

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(1)

(Total 8 marks)

- 29. (a) Explain how the connections of rod and cone cells with neurones in the retina give rise to differences in

- (i) sensitivity;

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- (ii) acuity.

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(3)

- (b) Explain why a person may be unable to see a dim star when looking straight at it, but can see it 'out of the corner of the eye'.

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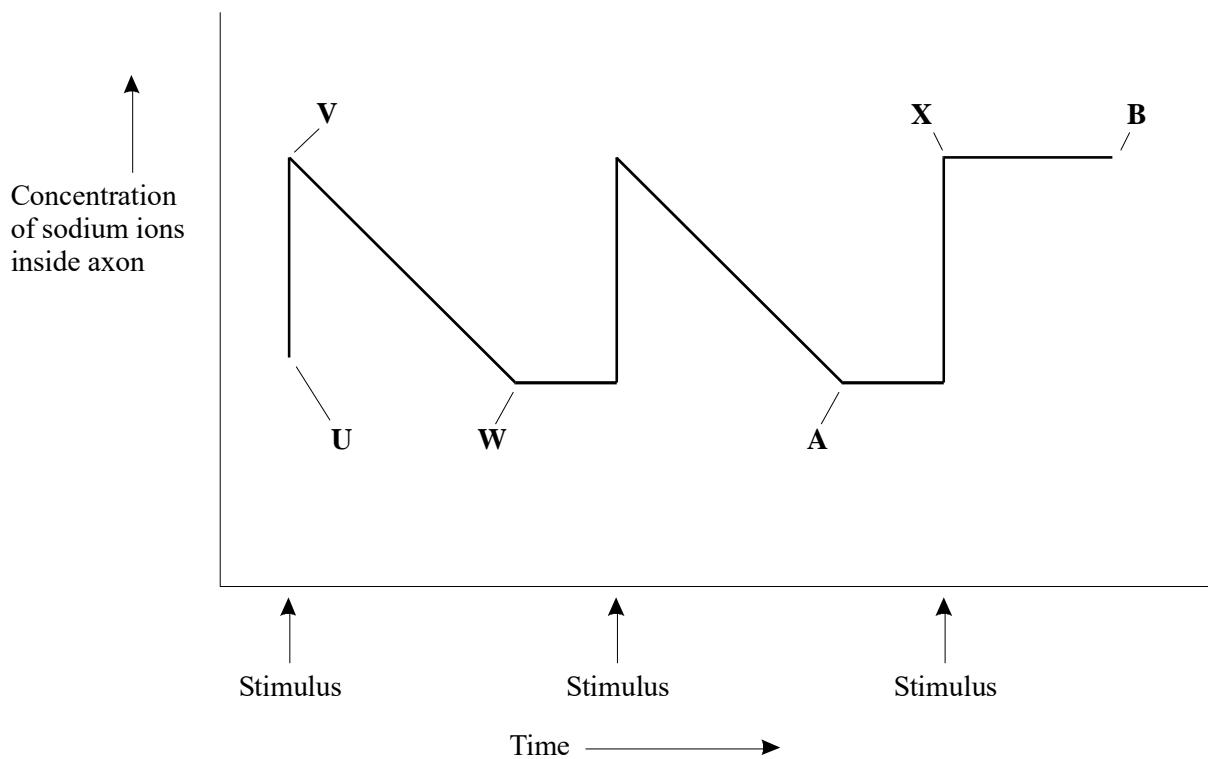
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(2)
(Total 5 marks)

30. The graph shows changes in concentration of sodium ions inside the axon of a large neurone. The axon was stimulated at the points indicated on the graph. Between **A** and **B** on the graph the neurone was treated with dinitrophenol. This prevents the reduction of **ATP**



(a) Explain the changes in sodium ion concentration

(i) between **U** and **V**;

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(2)

(ii) between **V** and **W**.

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(2)

(b) Explain why the concentration of sodium ions did **not** change between **X** and **B**.

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(2)

(Total 6 marks)

31. (a) Describe the sequence of events which leads to the transmission of an impulse at a cholinergic synapse.

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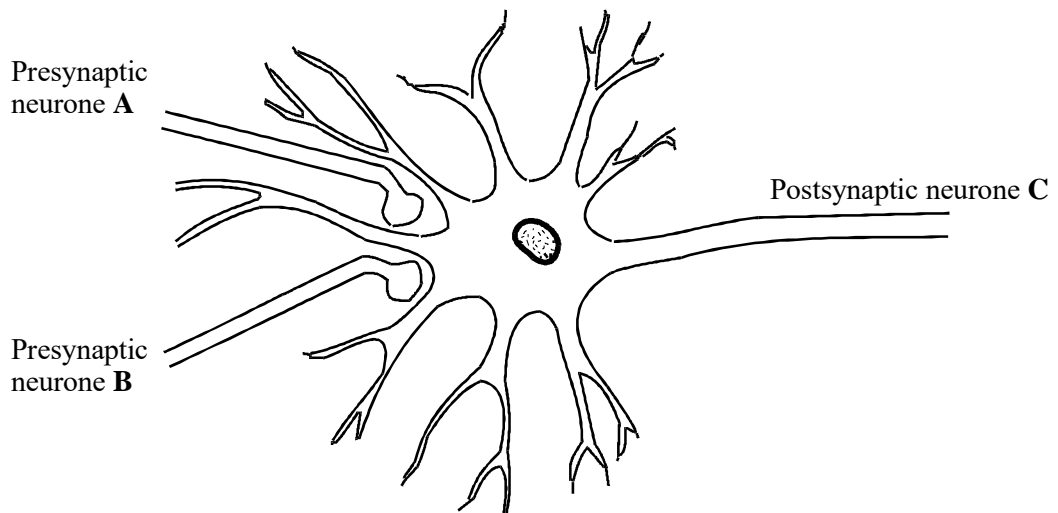
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(6)

- (b) The diagram shows axons from two presynaptic neurones, **A** and **B**, and the synapse they form with postsynaptic neurone, **C**.



The table shows the results of four experiments to determine the effects of action potentials in neurones **A** and **B** on neurone **C**.

| Experiment | Action potentials in presynaptic neurone(s) | Effect on neurone C |
|------------|---|----------------------------|
| 1 | Single action potential in A | No action potential |
| 2 | Single action potential in B | No action potential |
| 3 | Simultaneous action potentials in A and B | Action potential |
| 4 | Two action potentials in A in rapid succession | Action potential |

Explain why an action potential was produced in **C** in experiments 3 and 4, but not in experiments 1 and 2.

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(6)
(Total 12 marks)

32. (a) Describe how the resting potential is maintained across the cell surface membrane of a neurone.

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(3)

- (b) *Figure 1* shows the change in potential difference across the cell surface membrane of a neurone during the propagation of a nerve impulse.

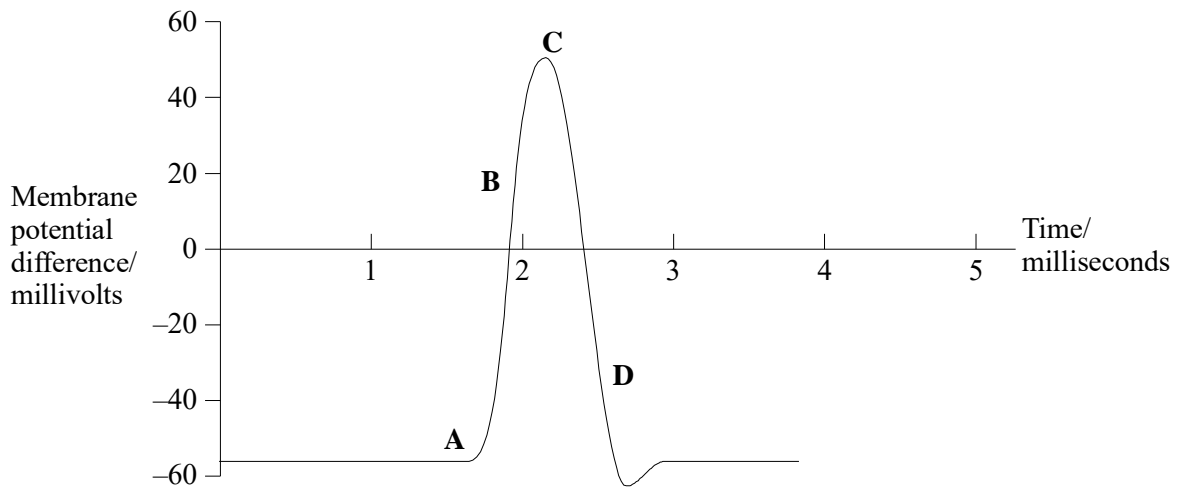


Figure 1

Explain in terms of ion movements, the change in potential difference which takes place between

- (i) points **A** and **B**;

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(2)

(ii) points **C** and **D**.

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(2)

(c) In an investigation into action potentials, neurones were placed in different solutions. The concentration of sodium ions in solution **X** was the same as in tissue fluid. The concentration in solution **Y** was only 30% of that found in tissue fluid. **Figure 2** shows the change in potential difference across the axon membranes after stimulation.

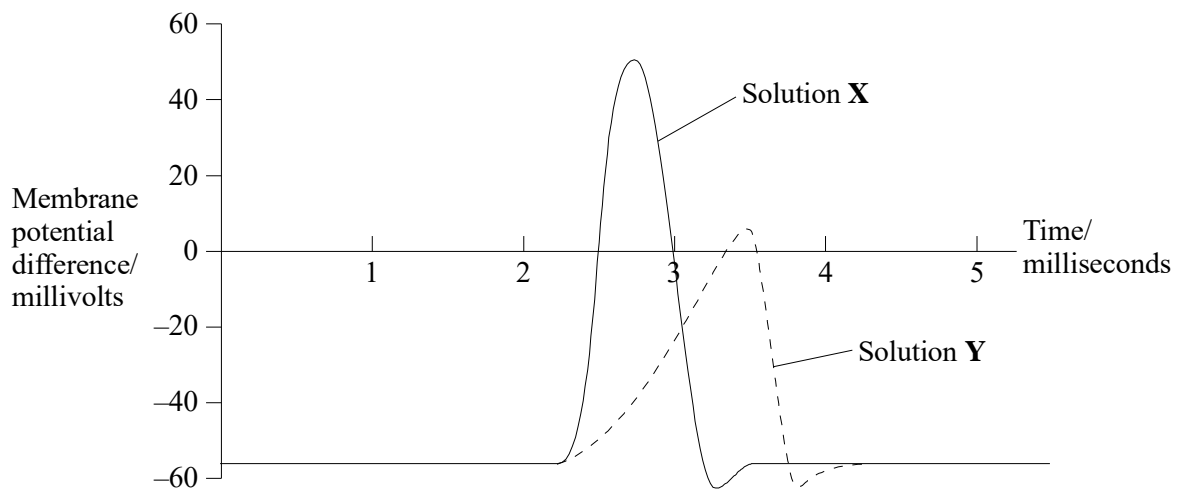


Figure 2

(i) Explain the difference in the size and shape of the curve obtained for the neurone placed in solution **Y**.

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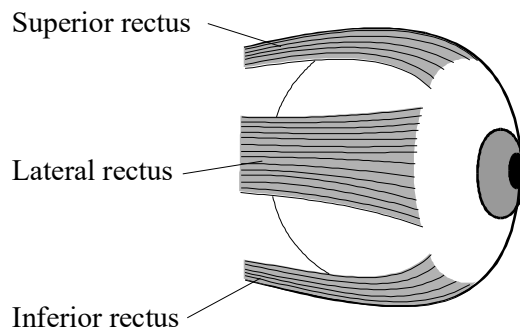
(2)

- (ii) Explain why it was not possible to produce a series of action potentials when a respiratory inhibitor was added to solution X.

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(1)
(Total 10 marks)

33. The drawing shows some of the muscles that move the eyeball.



- (a) Describe how information is transmitted across a neuromuscular junction when muscles of the eyeball are stimulated.

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(5)

- (b) Myasthenia gravis is a disorder that often affects the muscles of the eyeball. It is caused by antibodies (proteins) binding to the postsynaptic membrane of neuromuscular junctions. The muscles may cease to function. Anti-cholinesterase drugs have been used in the treatment of this disease.

Suggest and explain how

- (i) the antibodies may prevent contraction of muscles;

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(2)

- (ii) anti-cholinesterase drugs may help in the treatment of myasthenia gravis.

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(2)

(Total 9 marks)

34. (a) **Figure 1** shows a sodium channel protein in the cell surface membrane of a neurone.

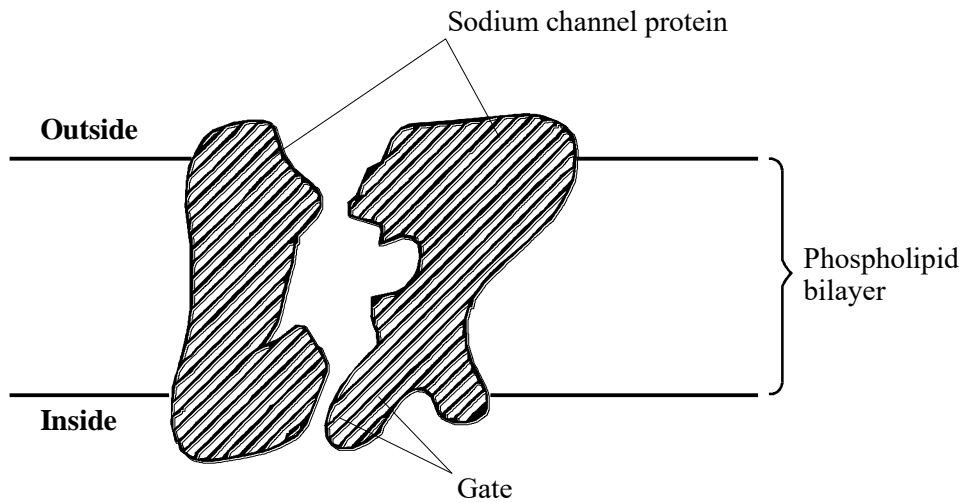


Figure 1

- (i) A change in potential difference will affect the gate on the channel protein and produce an action potential. Explain how the action potential is produced.

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(2)

- (ii) Describe what happens to the sodium ions immediately after the passage of an action potential along the neurone.

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(2)

- (b) Local anaesthetics are used by dentists to stop patients feeling pain. **Figure 2** shows how a molecule of a local anaesthetic binds to a sodium channel protein.

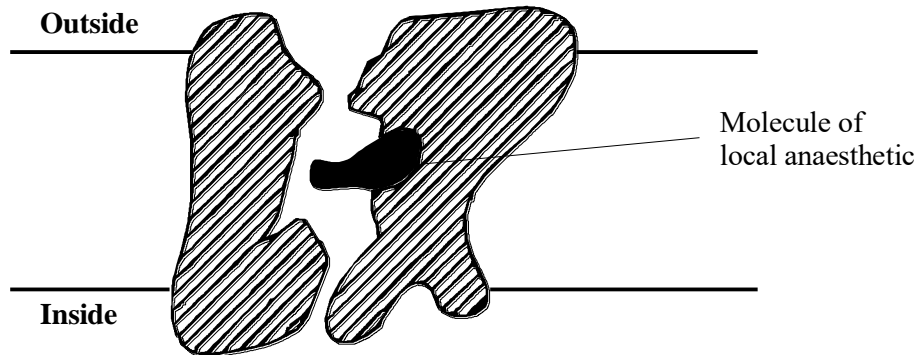


Figure 2

Explain how this local anaesthetic stops the patient feeling pain.

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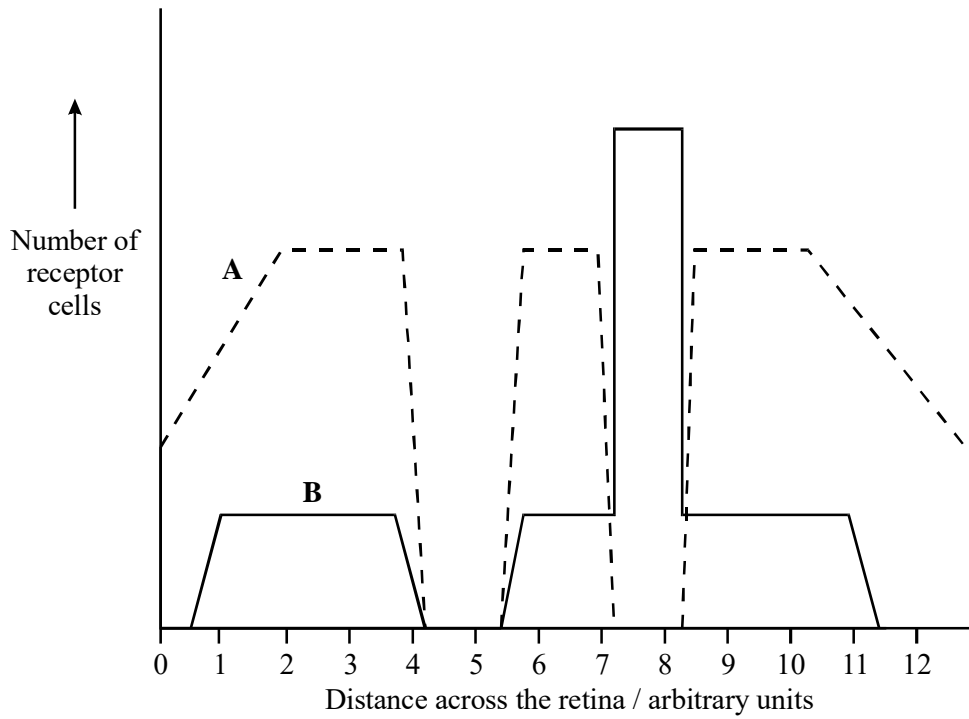
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(3)
(Total 7 marks)

35. The graph represents the number of receptor cells (types **A** and **B**) found along a horizontal line across the human retina.



(a) Name the two different types of receptor cell.

A

B

(1)

(b) Name the region of the retina at position 8.

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(1)

- (c) Explain why an object may be seen in greater detail if the image is focused at position 8, rather than at position 12.

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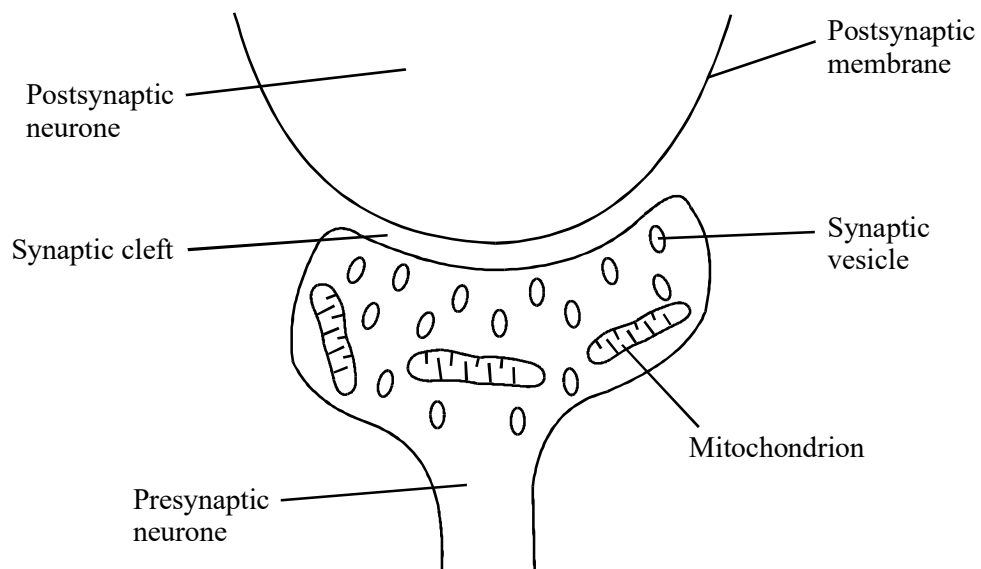
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(2)
(Total 4 marks)

36. The drawing shows a synapse in which acetylcholine acts as the transmitter substance.



(a) Describe the part played by acetylcholine in synaptic transmission.

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(3)

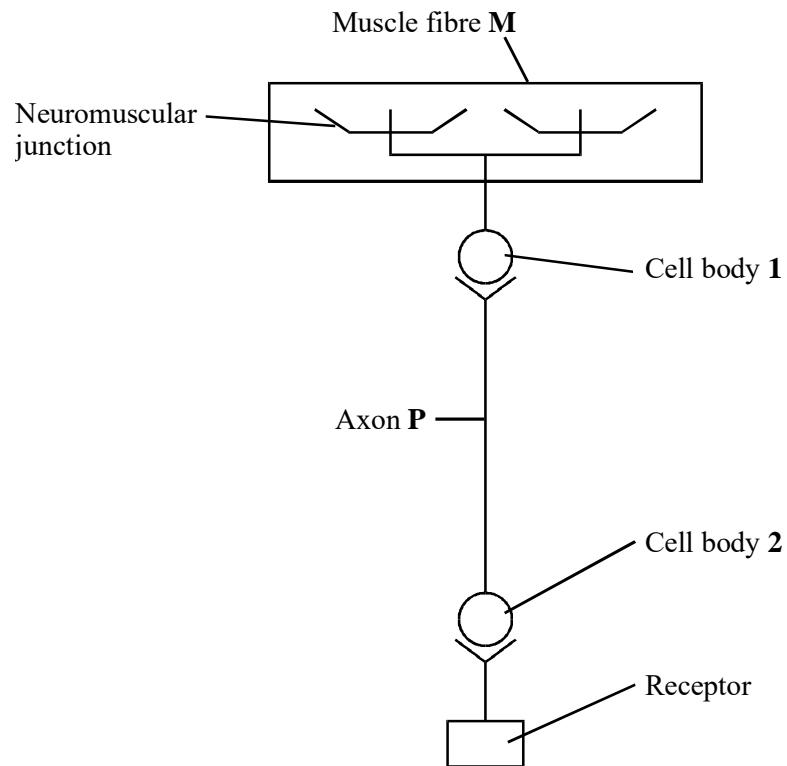
(b) Describe the function in synaptic transmission of the mitochondria shown.

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(1)

The diagram represents a nerve pathway found in a burrowing animal. Contraction of muscle fibre **M** helps to bring about an escape response in which the head of the animal is pulled quickly back into the burrow.



- (c) Explain how the escape response in this animal may be regarded as being controlled by a simple reflex arc.

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(d) Impulses are able to travel in either direction along an axon. Explain why impulses cannot pass from muscle fibre **M** to the receptor along the nerve pathway shown in the diagram.

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(1)

(e) Axon **P** was found to conduct impulses much faster than other axons in the animal.

(i) Describe one feature of axon **P** that might cause this difference.

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(1)

(ii) Suggest how the speed of conduction in axon **P** helps to adapt the animal to its environment.

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(1)

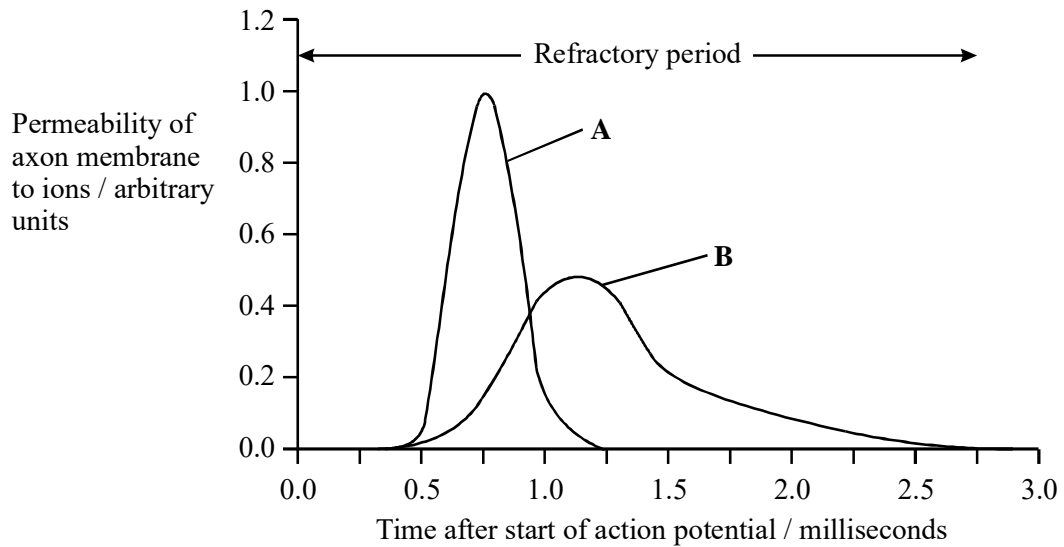
(Total 10 marks)

37. (a) Describe how a resting potential is maintained in an axon.

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(2)

- (b) The graph shows the changes in the permeability of a section of axon membrane to two ions involved in producing an action potential.



- (i) Identify ions **A** and **B**.

A

B

(1)

- (ii) Explain how movements of these ions are involved in producing the action potential.

.....

(2)

- (iii) What is meant by the *refractory period*?

.....

(1)

- (iv) Use the information in the graph to calculate the maximum frequency of action potentials per second along this axon. Show your working.

Answer action potentials s^{-1}

(2)

(Total 8 marks)

38. This question should be written in continuous prose, where appropriate.

- (a) Explain how a resting potential is maintained in a neurone.

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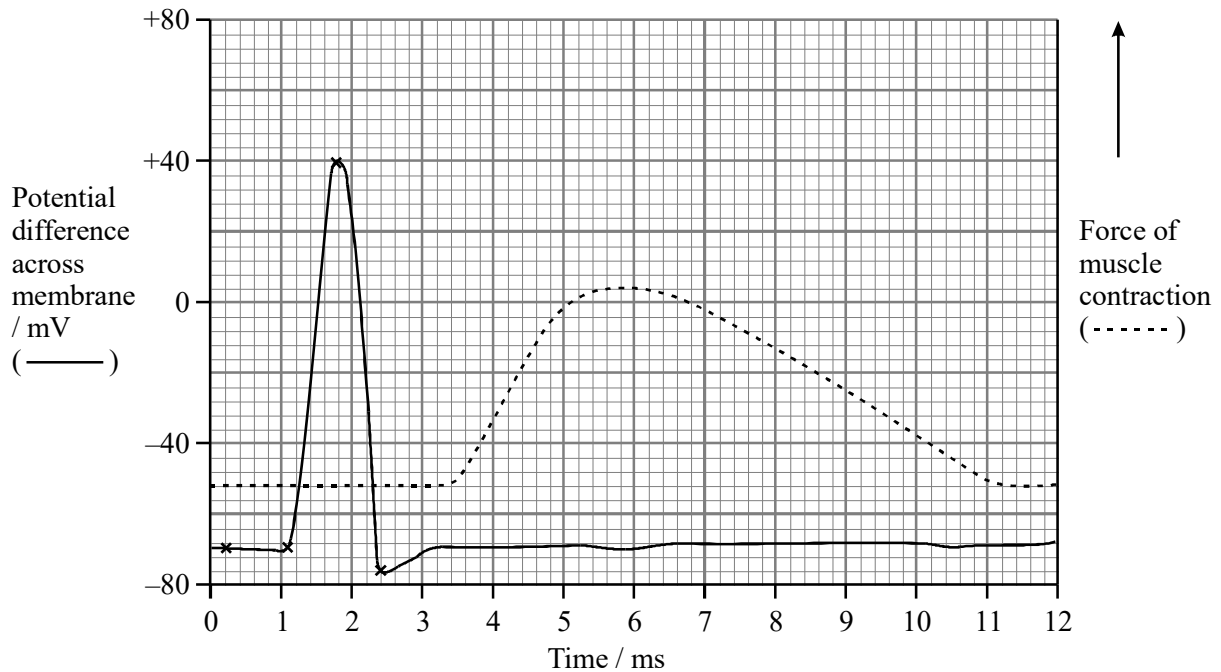
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(4)

- (b) In an investigation, an impulse was generated in a neurone using electrodes. During transmission along the neurone, an action potential was recorded at one point on the neurone. When the impulse reached the neuromuscular junction, it stimulated a muscle cell to contract. The force generated by the contraction was measured. The results are shown in the graph.

The distance between the point on the neurone where the action potential was measured and the neuromuscular junction was exactly 18 mm.



- (i) Use the graph to estimate the time between the maximum depolarisation and the start of contraction by the muscle cell.

Time ms

(1)

- (ii) Use your answer to part (i) to calculate the speed of transmission along this neurone to the muscle cell. Give your answer in mm per second. Show your working.

Speed mm s^{-1}

(2)

- (iii) Give **one** reason why the value calculated in part (ii) would be an underestimate of the speed of transmission of an impulse along a neurone.

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(1)

Acetylcholine is the neurotransmitter at neuromuscular junctions.

- (c) Describe how the release of acetylcholine into a neuromuscular junction causes the cell membrane of a muscle fibre to depolarise.

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(3)

- (d) Use your knowledge of the processes occurring at a neuromuscular junction to explain each of the following.

- (i) The cobra is a very poisonous snake. The molecular structure of cobra toxin is similar to the molecular structure of acetylcholine. The toxin permanently prevents muscle contraction.

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(2)

- (ii) The insecticide DFP combines with the active site of the enzyme acetylcholinesterase. The muscles stay contracted until the insecticide is lost from the neuromuscular junction.

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(2)

(Total 15 marks)

39. After moving from bright light into darkness, it takes several minutes for the rod cells to recover their sensitivity. Researchers measured the ability of the rod cells to detect small spots of light of different colours and intensity after a person moved into darkness.

The results are shown in **Figure 1**.

Figure 2 shows the amount of light of different wavelengths that rhodopsin absorbs.

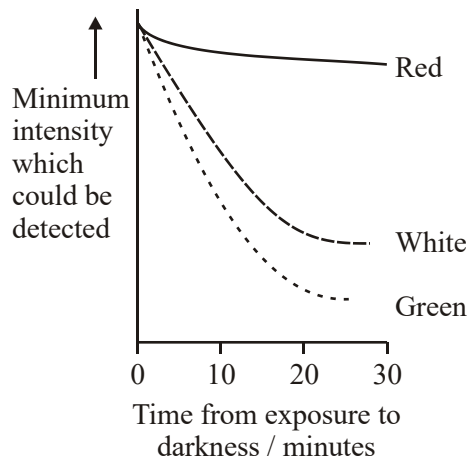


Figure 1

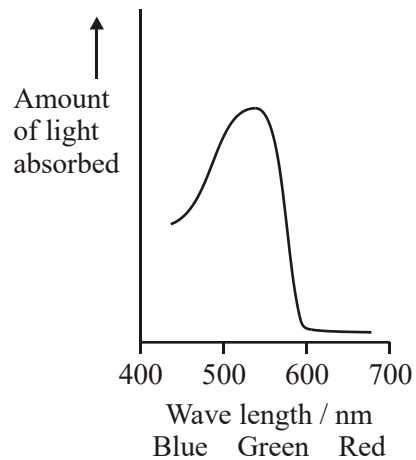


Figure 2

- (i) Explain why it takes time for the rod cells to recover their sensitivity to light after moving into darkness.

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(2)

- (ii) Use information in **Figures 1 and 2** to explain the differences in sensitivity of rod cells to red and green light.

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(2)

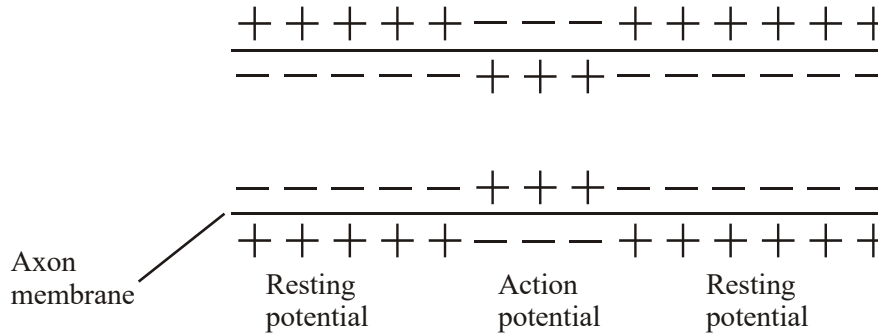
- (iii) Suggest an explanation for the difference in sensitivity of rod cells to the white and green spots after 30 minutes.

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(1)

(Total 5 marks)

40. The diagram shows the change in the charge across the surface membrane of a non-myelinated axon when an action potential is produced.



- (a) Describe how the change shown in the diagram occurs when an action potential is produced.

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(2)

- (b) Explain what causes the conduction of impulses along a non-myelinated axon to be slower than along a myelinated axon.

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(3)

(Total 5 marks)

41. S In an investigation, the effects of caffeine on performance during exercise were measured. One group of athletes (A) was given a drink of decaffeinated coffee. Another group (B) was given a drink of decaffeinated coffee with caffeine added. One hour later the athletes started riding an exercise bike and continued until too exhausted to carry on. Three days later the same athletes repeated the experiment, with the drinks exchanged.

(a) (i) The researchers added caffeine to decaffeinated coffee. Explain why they did not just use normal coffee.

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(1)

(ii) The performance of the athletes might have been influenced by how they expected the caffeine to affect them. How could the researchers avoid this possibility?

.....

(1)

During the exercise the concentrations of glycerol and fatty acids in the blood plasma were measured. The results are shown in the table.

| Drink | Mean time to exhaustion /minutes | Mean concentration of blood glycerol/ mmol dm^{-3} | Mean concentration of blood fatty acids/ mmol dm^{-3} |
|------------------|----------------------------------|---|--|
| With caffeine | 90.2 | 0.20 | 0.53 |
| Without caffeine | 75.5 | 0.09 | 0.31 |

(b) (i) Describe the effect of caffeine on exercise performance.

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(1)

- (ii) Suggest **one** explanation for the higher glycerol and fatty acid concentrations in the blood plasma of the athletes after they were given caffeine.

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(2)

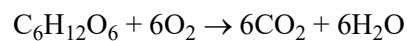
- (c) The researchers measured the volumes of carbon dioxide exhaled and oxygen inhaled during the exercise. From the results they calculated the respiratory quotient (RQ), using the formula

$$\text{RQ} = \frac{\text{volume of carbon dioxide exhaled per minute}}{\text{volume of oxygen inhaled per minute}}$$

When a person is respiring carbohydrate only, RQ = 1.0

When a person is respiring fatty acids only, RQ = 0.7

- (i) The basic equation for the respiration of glucose is



Explain why the RQ for glucose is 1.0.

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(2)

- (ii) The researchers found that, when the athletes were given the drink containing caffeine, their mean RQ was 0.85. When given the drink without caffeine their mean RQ was 0.92.

The researchers concluded that when the athletes had caffeine they used glycogen more slowly than when they did not have caffeine, and that the store of glycogen in their muscles was used up less quickly during the exercise.

Explain the evidence from the information above and from the table which supports these conclusions.

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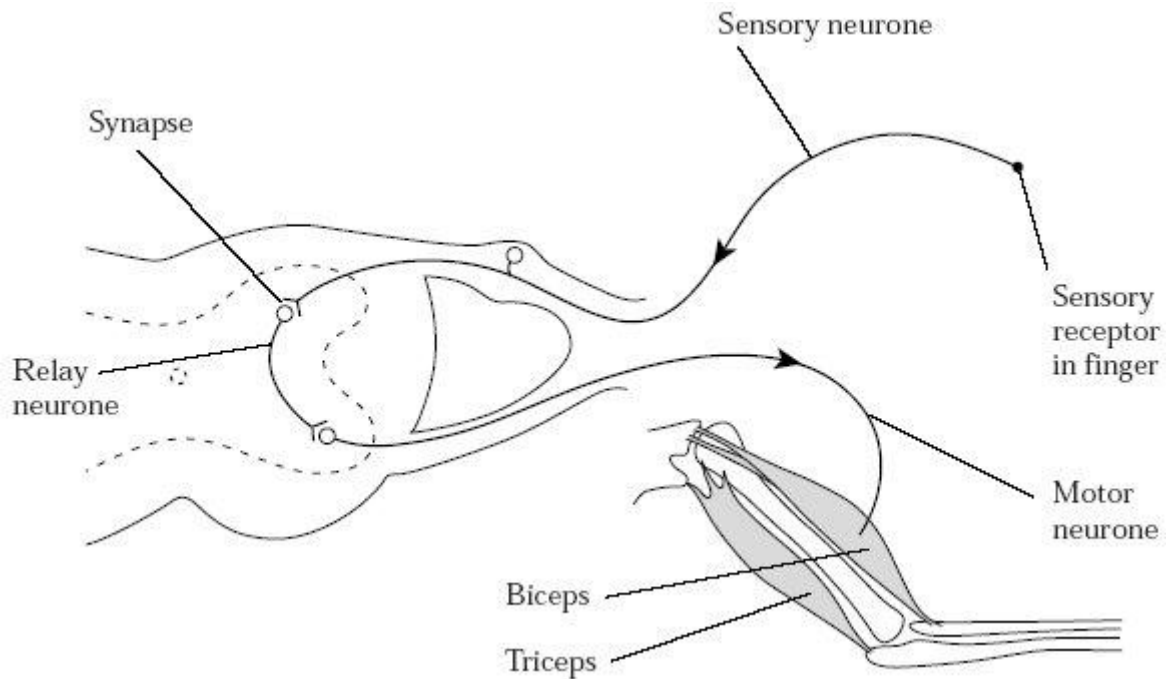
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(3)
(Total 10 marks)

42. When a finger accidentally touches a hot object, a reflex action occurs. The biceps muscle contracts, causing the arm to be flexed and the finger is pulled away. The diagram shows the arrangement of the bones in the arm, the muscles used for flexing and straightening the arm and the nervous pathways associated with the contraction of these muscles.



- (a) Explain the importance of reflex actions.

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(b) (i) Describe the sequence of events which allows information to pass from one neurone to the next neurone across a cholinergic synapse.

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(6)

(ii) Give **two** differences between a cholinergic synapse and a neuromuscular junction.

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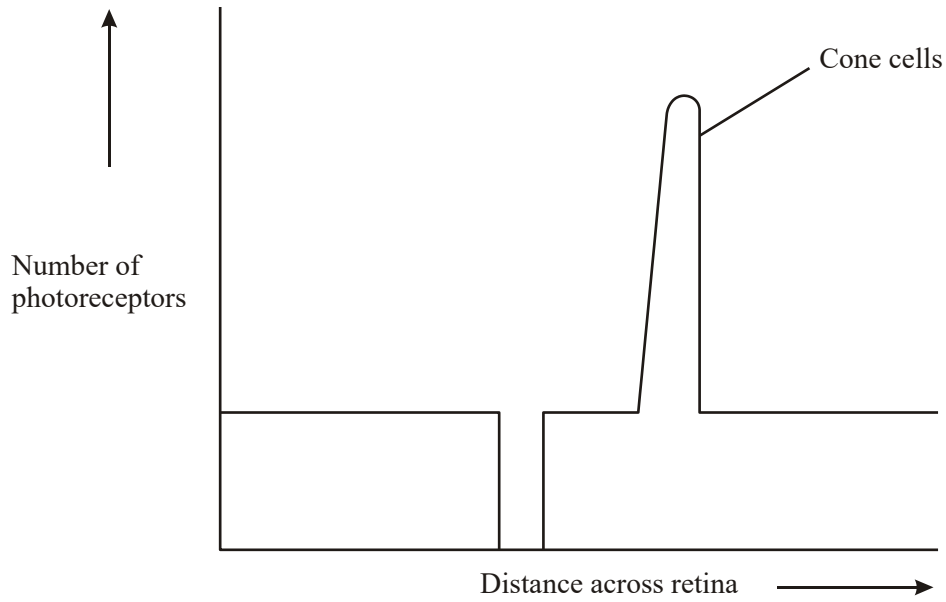
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(2)

(Total 11 marks)

43. The diagram shows the distribution of cone cells across the retina of a human eye.



(a) On the diagram draw a line to show the distribution of rod cells across the retina.

(2)

(b) Nocturnal mammals are active at night. Describe how the number and distribution of rods and cones across the retina would differ in a nocturnal mammal from the number and distribution in a human. Explain your answer.

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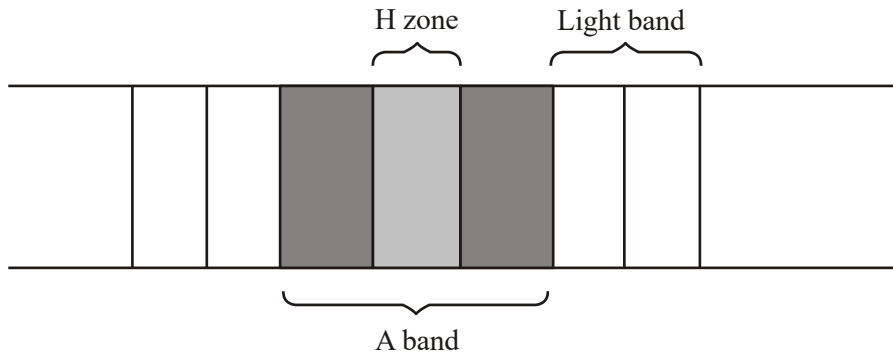
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(3)
(Total 5 marks)

44. (a) The diagram shows the banding pattern observed in part of a relaxed muscle fibril.



(i) Describe what causes the different bands seen in the muscle fibril.

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(2)

(ii) Describe how the banding pattern will be different when the muscle fibril is contracted.

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(2)

- (d) There is an increase in the activity of the enzyme ATPase during muscle contraction. An investigation into muscle contraction involved measuring the activity of ATPase in solutions containing ATP, myosin and different muscle components. The table shows the results.

| Solution | Contents | ATPase activity / arbitrary units |
|-----------------|--|--|
| A | ATP, myosin and actin | 1.97 |
| B | ATP, myosin, actin and tropomyosin | 0.54 |
| C | ATP, myosin, actin, tropomyosin and calcium ions | 3.85 |

- (i) Explain the importance of ATPase during muscle contraction.

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(2)

(ii) Using your knowledge of muscle contraction, explain the difference in the results between

A and B;

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.....

.....

(2)

B and C.

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.....

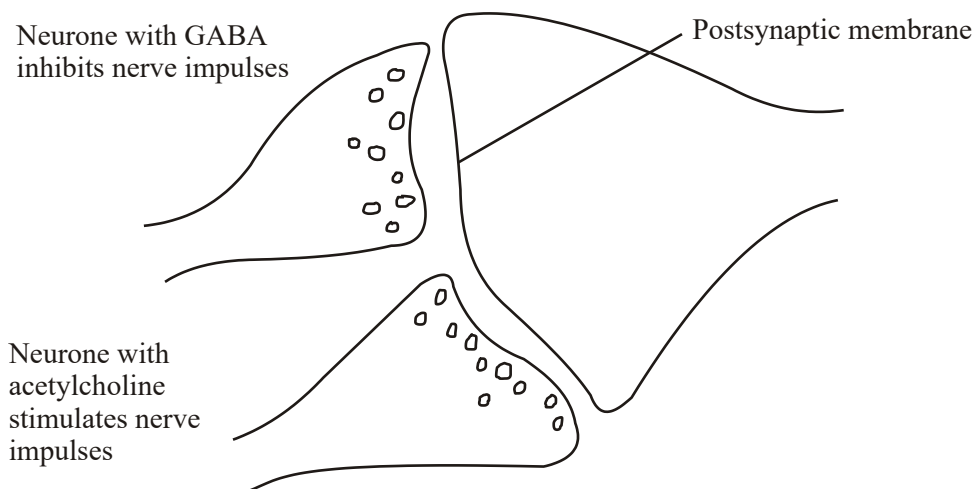
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(2)

(Total 10 marks)

45. Acetylcholine is a neurotransmitter which binds to postsynaptic membranes and stimulates the production of nerve impulses. GABA is another neurotransmitter. It is produced by certain neurones in the brain and spinal cord. GABA binds to postsynaptic membranes and inhibits the production of nerve impulses. The diagram shows a synapse involving three neurones.



- (a) Describe the sequence of events leading to the release of acetylcholine and its binding to the postsynaptic membrane.

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(4)

- (b) The binding of GABA to receptors on postsynaptic membranes causes negatively charged chloride ions to enter postsynaptic neurones. Explain how this will inhibit transmission of nerve impulses by postsynaptic neurones.

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(3)

(c) Epilepsy may result when there is increased neuronal activity in the brain.

(i) One form of epilepsy is due to insufficient GABA. GABA is broken down on the postsynaptic membrane by the enzyme GABA transaminase. Vigabatrin is a new drug being used to treat this form of epilepsy. The drug has a similar molecular structure to GABA. Suggest how Vigabatrin may be effective in treating this form of epilepsy.

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(2)

(ii) A different form of epilepsy has been linked to an abnormality in GABA receptors. Suggest and explain how an abnormality in GABA receptors may result in epilepsy.

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(3)

(Total 12 marks)

46. (a) Effectors bring about responses in the body. They are stimulated when neurones secrete substances, called neurotransmitters, on to them.

(i) Name the type of neurone that stimulates muscles.

.....

(1)

- (ii) Other than muscle tissue, name **one** type of tissue that acts as an effector.

.....

(1)

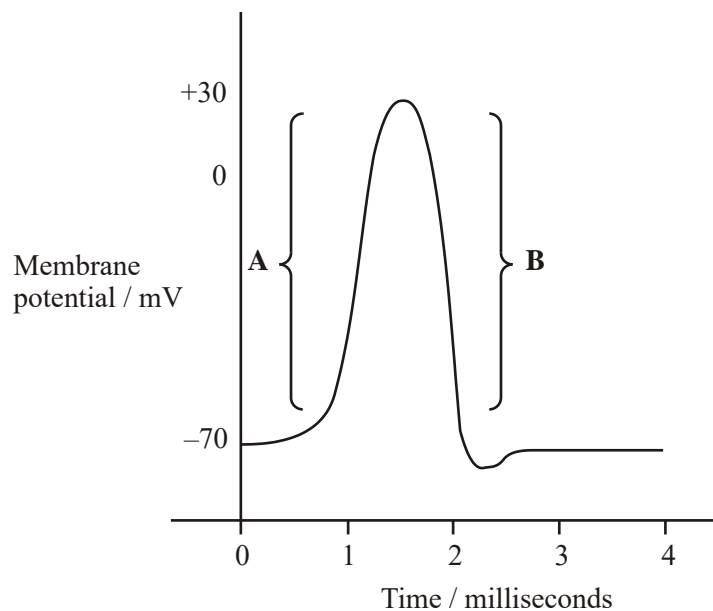
- (b) Substances, called hormones, can also stimulate effectors.
Humans produce a large number of different hormones but only a small number of different neurotransmitters. Explain the significance of this difference.

.....

(3)

(Total 5 marks)

47. The graph shows the electrical changes measured across the plasma membrane of an axon during the passage of a single action potential.



(a) Explain the shape of the curve

(i) over the range labelled **A**;

.....
.....
.....
.....

(2)

(ii) over the range labelled **B**;

.....
.....

(1)

(b) Fewer action potentials occur along a myelinated axon than along an unmyelinated axon of the same length. Explain why.

.....
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.....

(2)

(Total 5 marks)