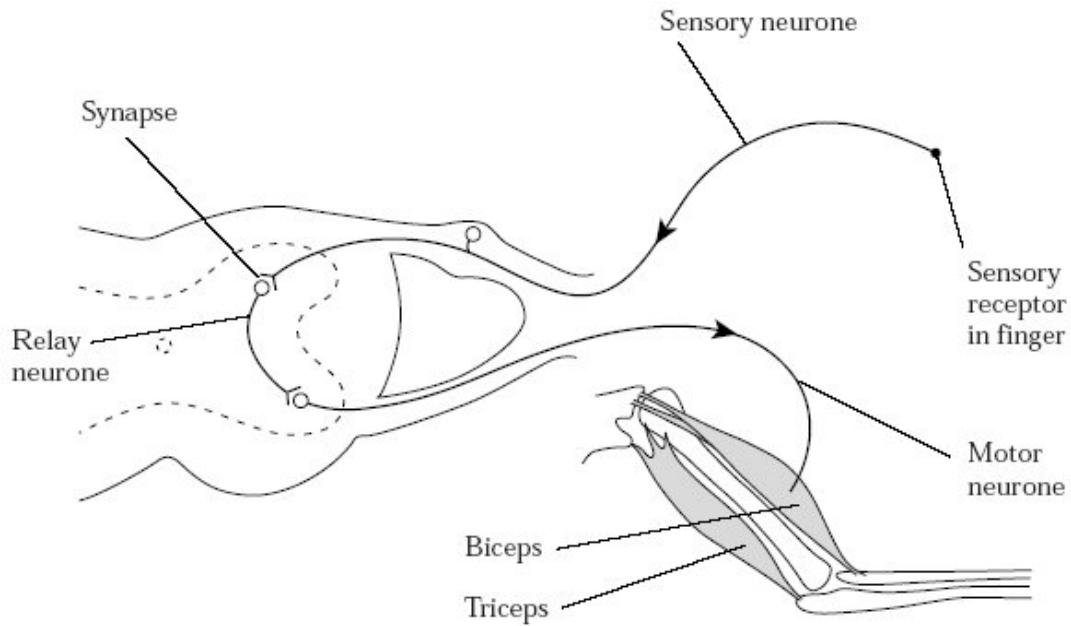


Q1. When a finger accidentally touches a hot object, a reflex action occurs. The biceps muscle contracts, causing the arm to be flexed and the finger is pulled away. The diagram shows the arrangement of the bones in the arm, the muscles used for flexing and straightening the arm and the nervous pathways associated with the contraction of these muscles.



(a) Explain the importance of reflex actions.

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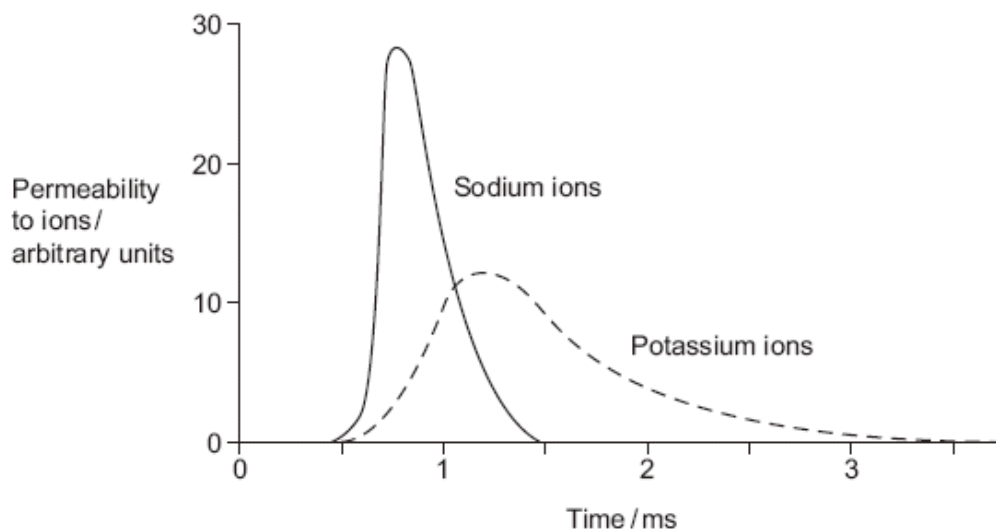
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(3)

Q2. 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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(3)

(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)

- Q3.** (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.

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(1)

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

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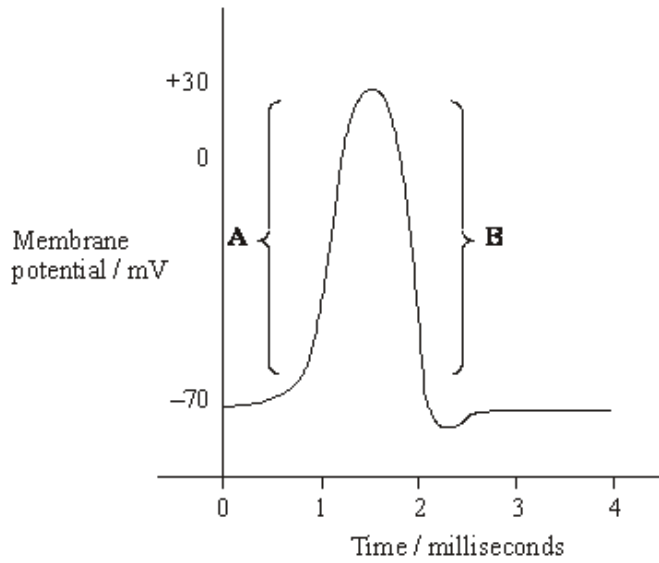
(1)

- (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.

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(3)
(Total 5 marks)

Q4. 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**;

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(2)

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

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(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)

Q5. 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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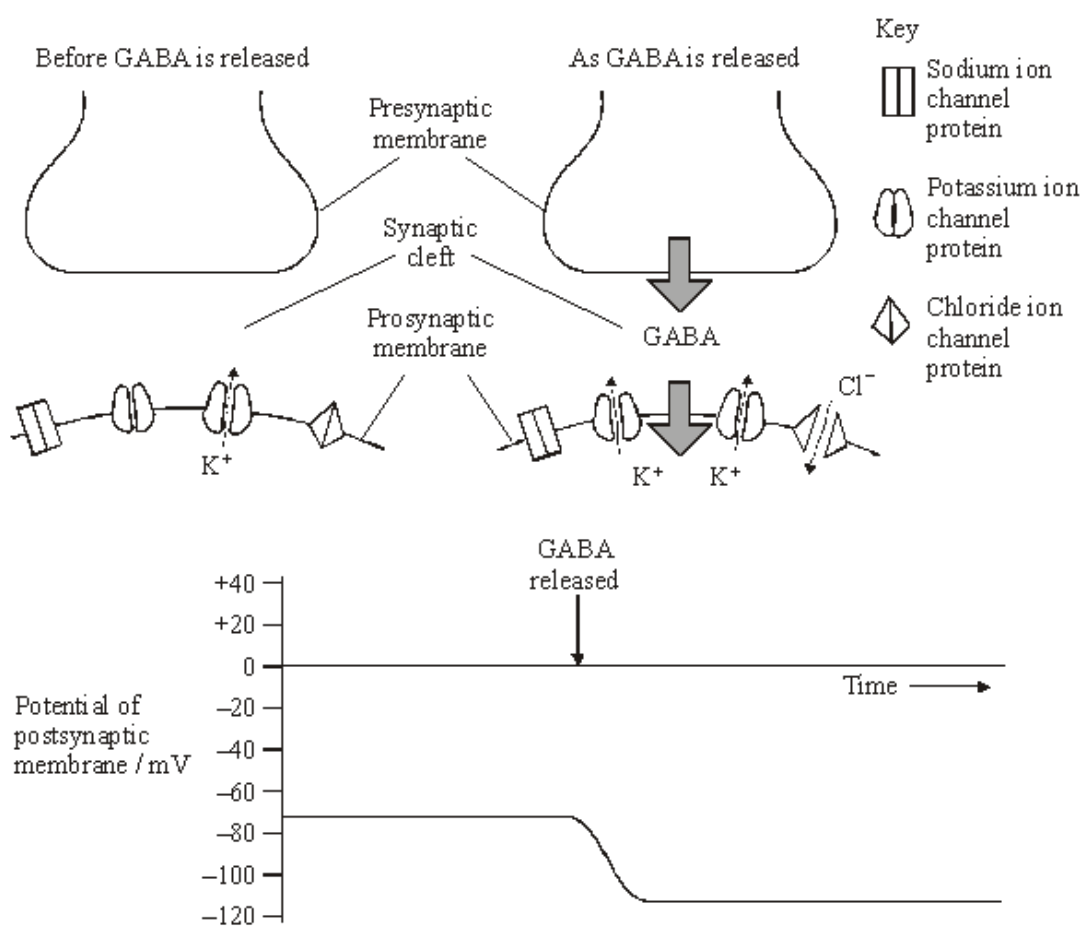
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(2)

(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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(4)
(Total 8 marks)

Q6. 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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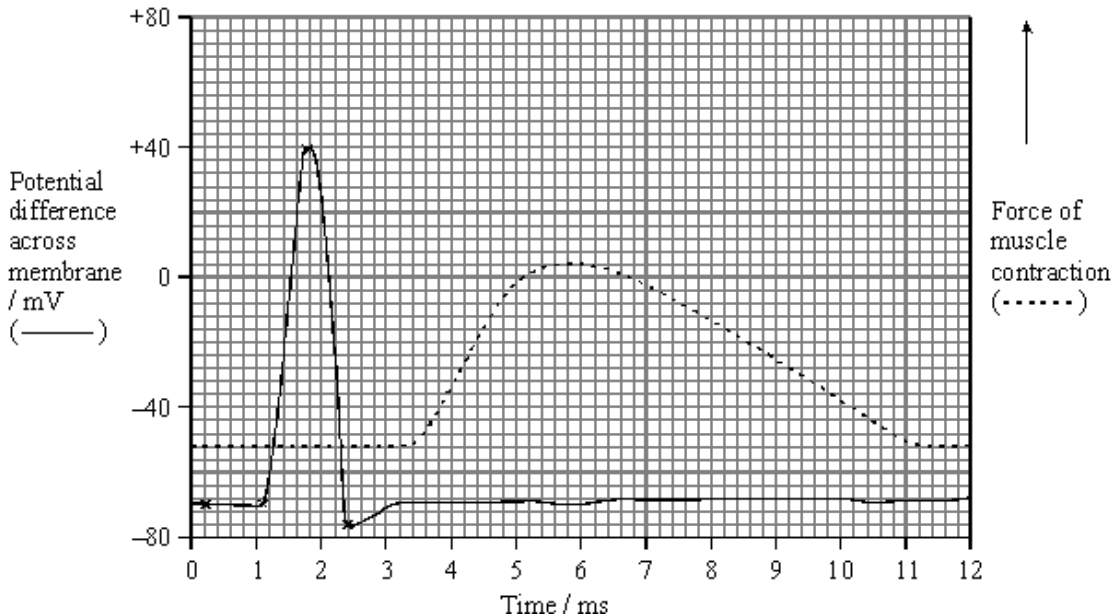
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(4)

- (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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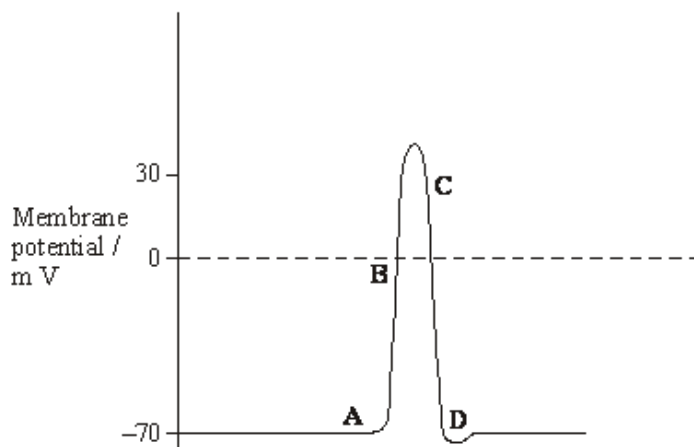
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(2)

(Total 15 marks)

- Q7. (a) **Figure 1** shows the changes in membrane potential at one point on an axon when an action potential is generated.

Figure 1



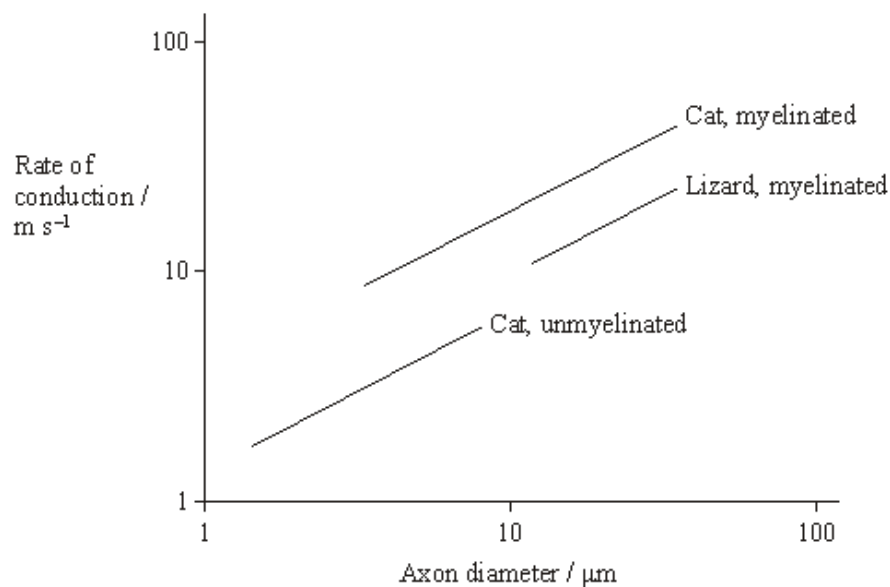
The changes shown in **Figure 1** are due to the movement of ions across the axon membrane. Complete the table by giving the letter (A to D) that shows where each process is occurring most rapidly.

| 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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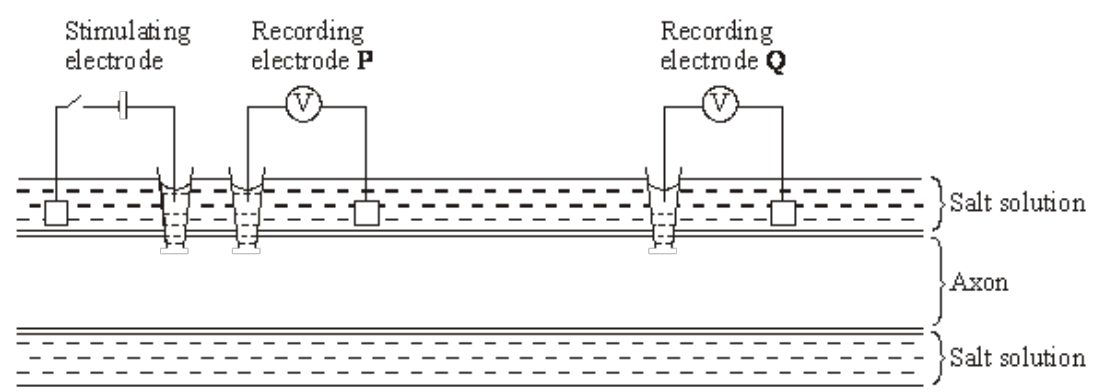
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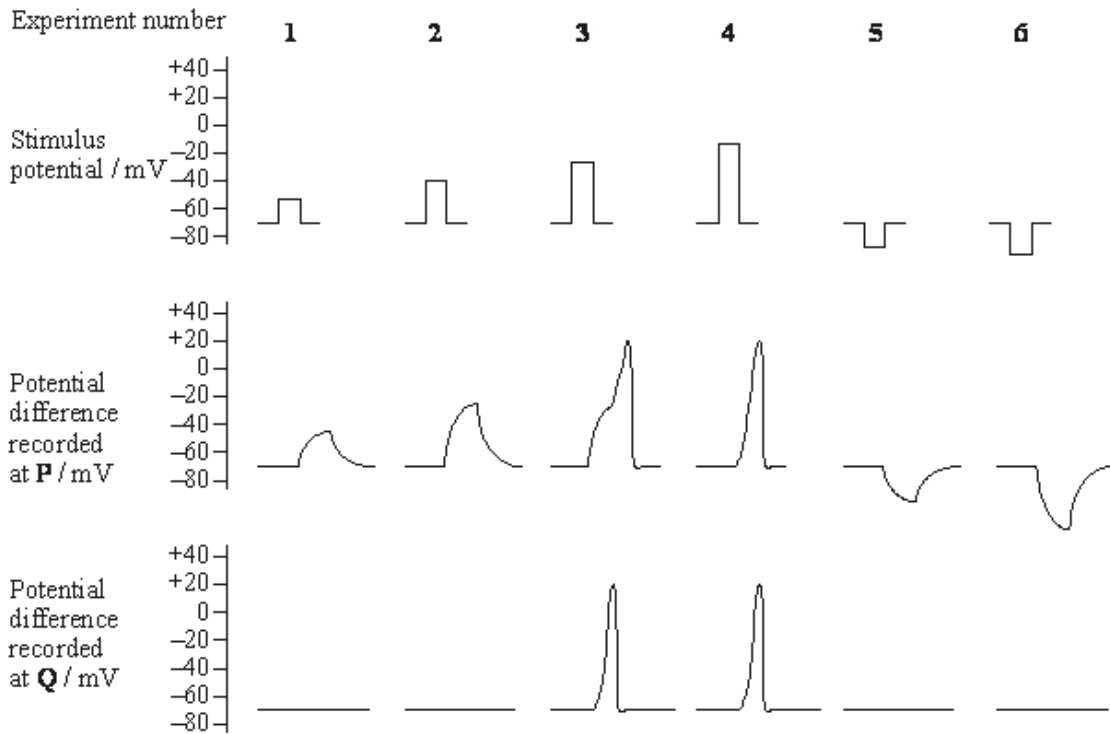
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(2)

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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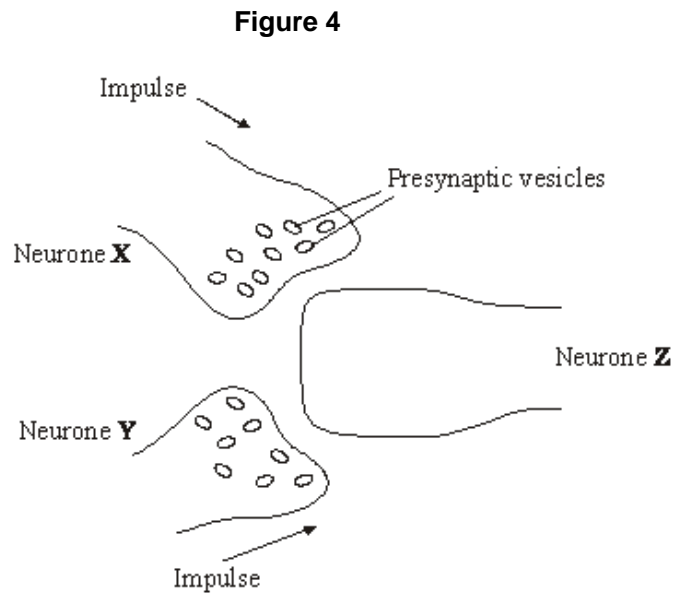
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(5)

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



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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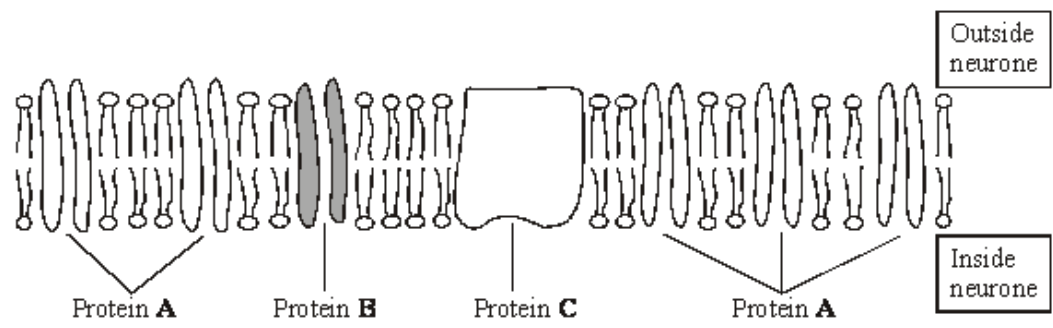
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(4)
(Total 15 marks)

Q8. 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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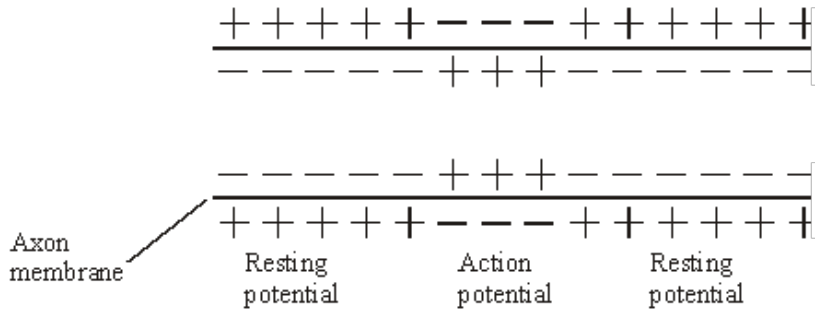
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(1)

(Total 5 marks)

Q9. 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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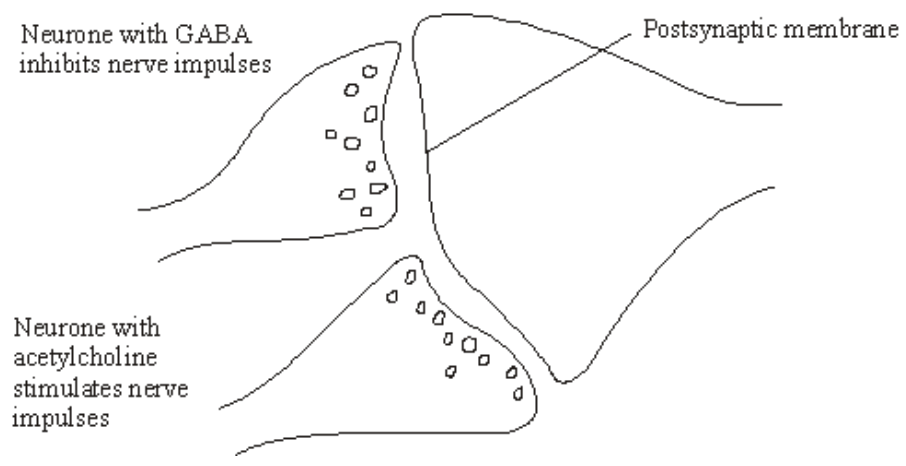
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(3)

(Total 5 marks)

Q10. 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)

Q11. (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)

