IB · HL · Biology

2 hours 15 questions

Structured Questions

# Neural Signalling

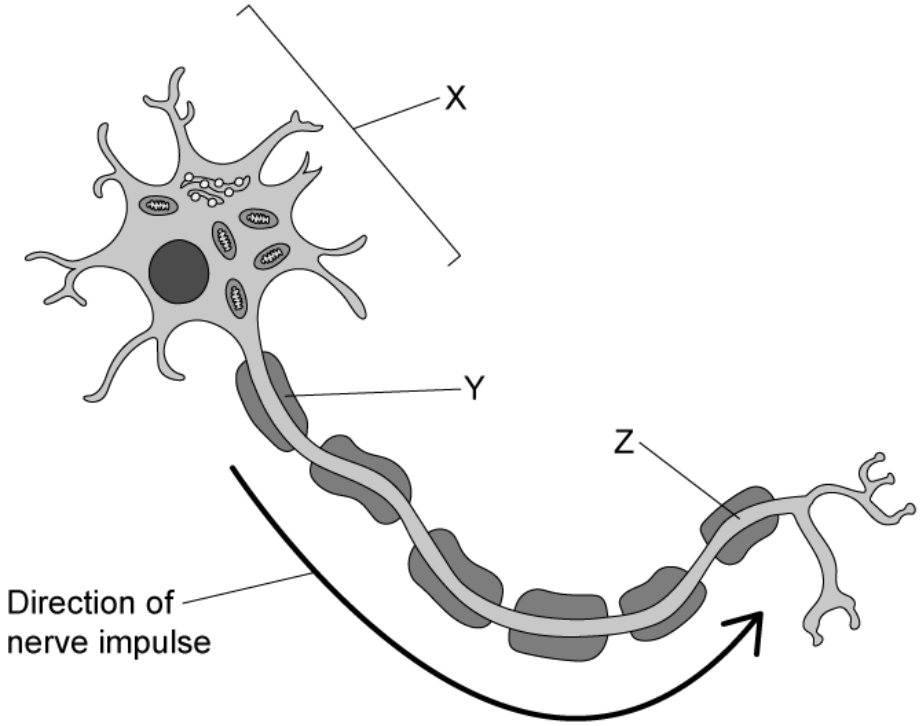
Neurones: Function & Structure / Nerve Impulses / Nerve Impulses: Skills / Synapses / Action Potentials (HL) / Interpreting Oscilloscope Traces: Skills (HL) / Nerve Conduction Velocity (HL) / Synaptic Transmission (HL) / Neurones in the Brain (HL)

| | |
|---|---|
| Easy (5 questions) | /40 |
| Medium (5 questions) | /49 |
| Hard (5 questions) | /55 |
| **Total Marks** | **/144** |

**Scan here to return to the course**
or visit savemyexams.com

# Easy Questions

**1 (a)** The image shows a representation of a neurone.




Identify structures **X-Z** in the image.

.....

.....

.....

**(3 marks)**

**(b)** Branching from structure **X** of the neurone in part a) are structures known as dendrites.

State the role of dendrites in the nervous system.

.....

**(1 mark)**

**(c)** Describe the structure of **Y** from the image in part a).

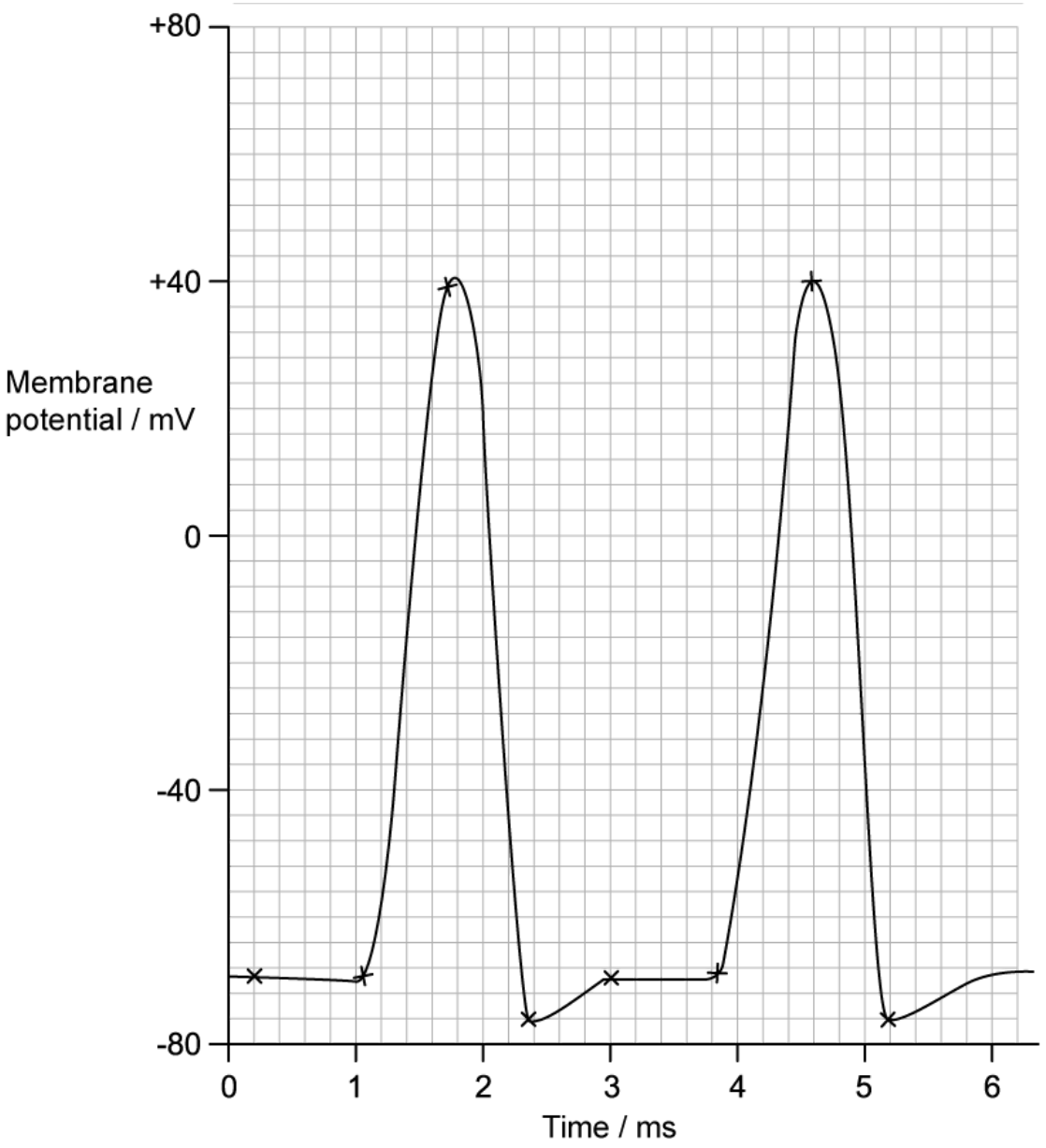
**(2 marks)**

**(d)** It has been estimated that a neurone **without** structure **Y** present can conduct nerve impulses at speeds of 0.5 m $s^{-1}$ whereas a neurone **with** structure **Y** present can conduct impulses at speeds of 150 m $s^{-1}$.

Calculate how many times faster impulse conduction is in the presence of structure **Y** than without structure **Y**.

**(2 marks)**

**2 (a)** The graph below shows changing membrane potential in an axon within a human leg.




At 0.5 ms:

(i) Identify the type of membrane potential present in the axon.

[1]

(ii) Explain how this membrane potential has been achieved.

[2]

**(3 marks)**

**(b)** At 1 ms in the graph in part a) the membrane is stimulated.

State what happens within the membrane at 1 ms as a result of this stimulation.

**(1 mark)**

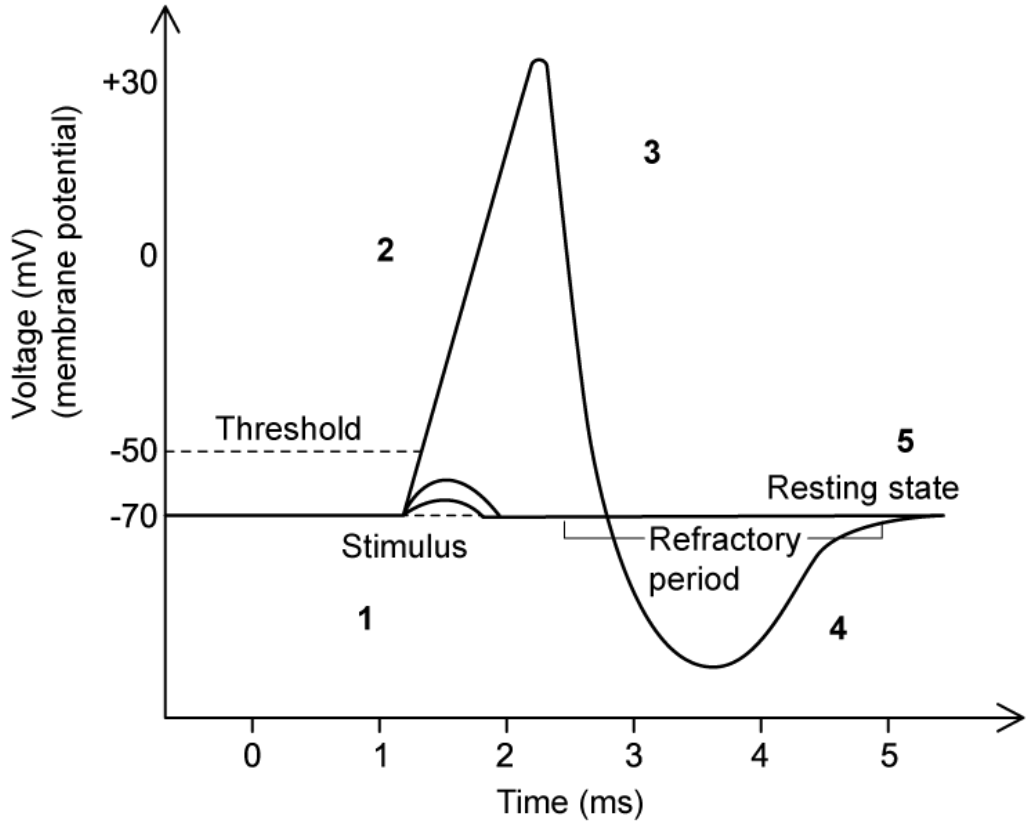
**(c)** Explain the shape of the curve between 1 - 1.8 ms in the graph in part a).

**(3 marks)**

**(d)** Assuming the intensity of stimulation remains constant, calculate how many complete action potentials will occur in 1 second in the graph shown in part a). Note that there are 1000 ms in a second.

**(2 marks)**

**3 (a)** The graph below shows the changes in membrane potential that take place in a neurone during a single action potential.




Stages **1** and **5** can be identified as the neurone in its resting state, and during stage **4** the neurone is said to be hyperpolarised.

Identify stages **2** and **3** in the graph.

.....

.....

**(2 marks)**

**(b)** Explain the change in membrane potential taking place during stage **3** in the graph in part a).

.....

.....

**(2 marks)**

**(c)** The table below contains a series of statements that describe the propagation of a nerve impulse a long an axon.

| | |
|---|---|
| | Sodium ions diffuse along the inside of the axon from an area of high concentration to an area of low concentration |
| | A new action potential is generated in the neighbouring section of the axon |
| | The recent influx of sodium ions creates a sodium gradient between the stimulated part of the axon and the neighbouring section. |
| | If a depolarisation threshold is reached new sodium ion channels open |

Identify the correct sequence of events by writing the numbers **1-4** in the blank boxes. The first event should be number **1**, and so on.

.....

.....

.....

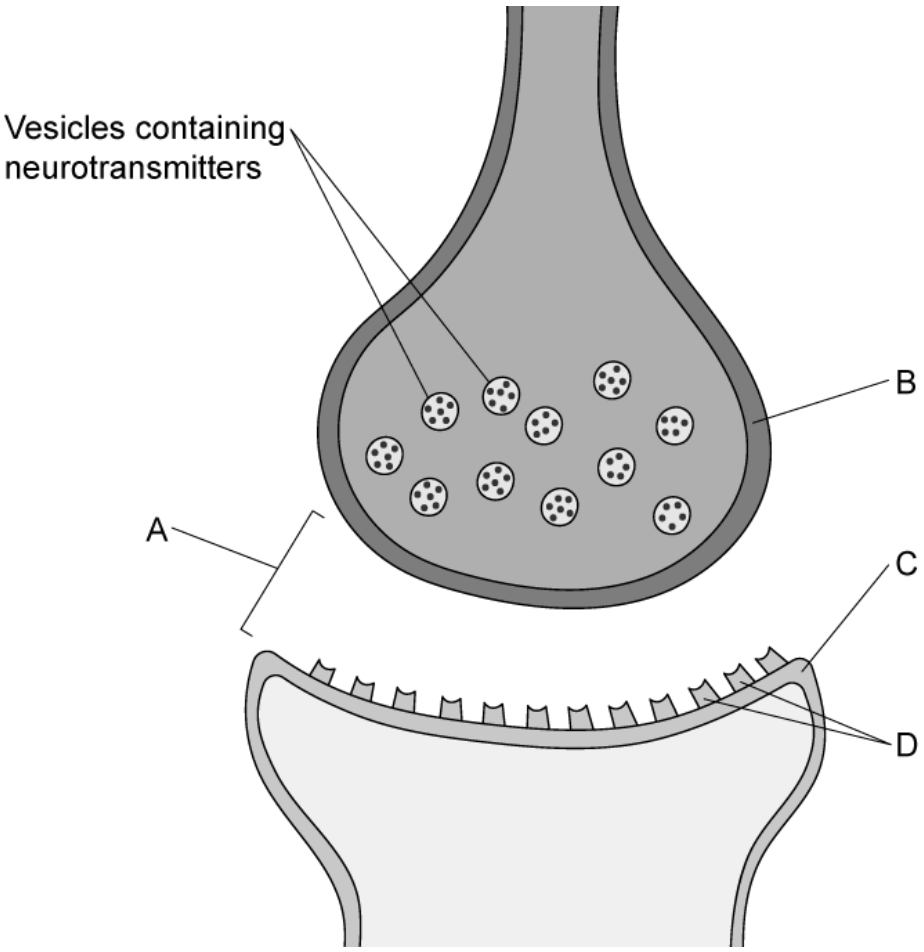
**(3 marks)**

**(d)** State the role of the refractory period in the propagation of action potentials.

.....

**(1 mark)**

**4 (a)** The image below shows a representation of a junction between two neurones.




Identify structures **A-C**.

.....

.....

.....

**(3 marks)**

**(b)** Part a) shows that the junctions between neurones contain molecules known as neurotransmitters.

Outline how neurotransmitters interact with the structures labelled **D** to bring about an action potential in the new neurone.

.....

**(2 marks)**

**(c)** Once its role is complete the neurotransmitter needs to be broken down and recycled in order for the junction between neurones to continue functioning.

Identify an enzyme that is involved with the breakdown of neurotransmitter molecules.

**(1 mark)**

**(d)** Neonicotinoids are chemicals used in some types of pesticide. Neonicotinoids have a similar function to certain neurotransmitters in the nervous systems of insects, with one major difference being that the enzyme in part c) cannot break them down.

Suggest why the enzyme in part c) cannot break down neonicotinoids.

**(1 mark)**

**5 (a)** Outline the role of the myelin sheath in nerve transmission.

**(3 marks)**

**(b)** Draw a labelled diagram of a neurone.

**(5 marks)**

# Medium Questions

**1 (a)** Describe and explain **one** way in which an axon may be adapted to conduct impulses at a faster rate in the nervous system.

.....

**(1 mark)**

**(b)** The presence of myelin around an axon can help speed up a nerve impulse.

Explain how.

.....

.....

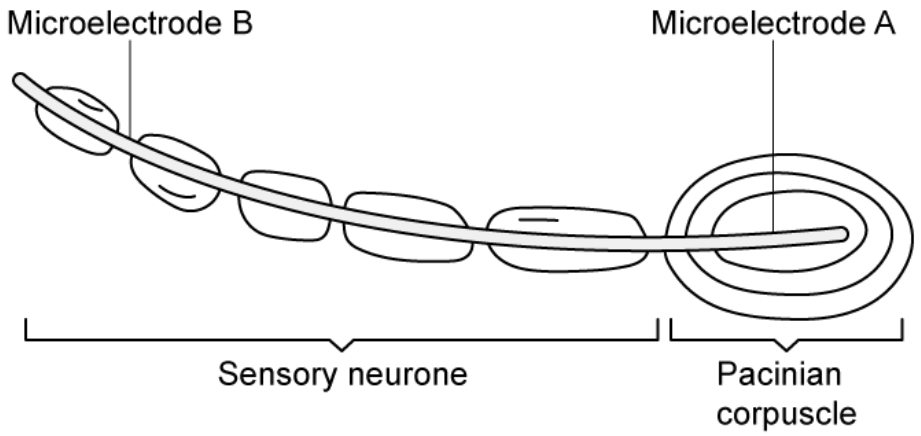
.....

**(3 marks)**

**(c)** Pacinian corpuscles are one of many receptors found in the skin. They detect changes in pressure.

A scientist wanted to research the effects of different pressures on the magnitude of membrane potentials generated. They investigated this effect by connecting multiple microelectrodes to the end of a toe and applying different pressures to the toe. The microelectrodes measured the maximum membrane potential of the pacinian corpuscle and its associated neurone, called a sensory neurone, when different pressures were applied.

The diagram below shows the structure of the Pacinian corpuscle, along with its sensory neurone and the position of the microelectrodes.




The table below shows the results.

| Pressure applied to the end of the toe | Membrane potential at A (mV) | Membrane potential at B (mV) |
|---|---|---|
| None | -70 | -70 |
| Light | -45 | -70 |
| Medium | +35 | +40 |
| Heavy | +40 | +40 |

Explain how the sensory neurone within the Pacinian corpuscle maintains a resting potential when no pressure is applied.

.....

.....

**(2 marks)**

**(d)** The membrane potential measured at microelectrode **B** (from part c of question 1) was identical for both medium and heavy pressure.

Explain why.

.....

.....

**(2 marks)**

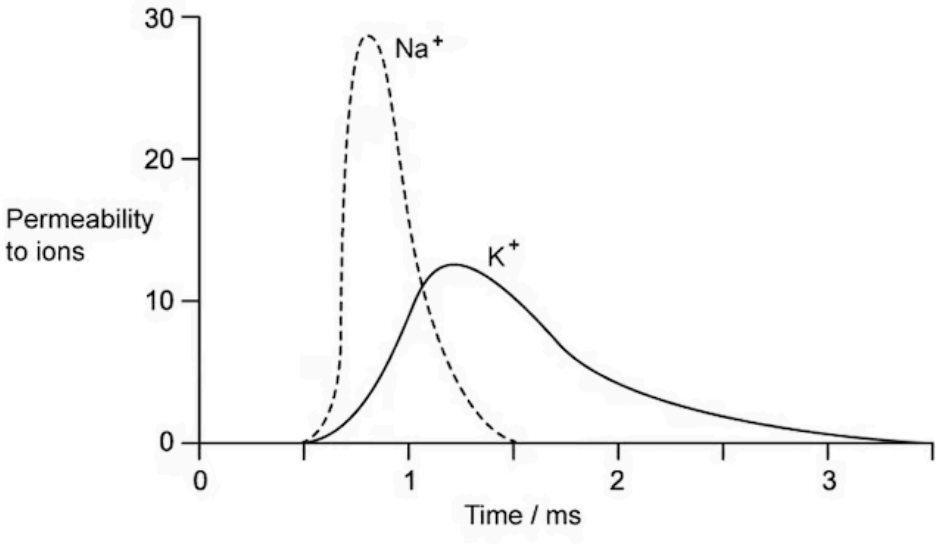
**2 (a)** Body temperature can affect the speed of an action potential. Research has found that reaction time is slower when body temperature falls. This is because nerve impulse conduction is slower.

Explain how a lower temperature leads to slower nerve impulse conduction.

**(2 marks)**

**(b)** The permeability of the axon's cell-surface membrane changes during an action potential.

The graph below shows changes in permeability of the membrane during a single action potential to both sodium ($Na^+$) and potassium ($K^+$) ions.




Explain the steep increase in sodium ion permeability seen between 0.5 ms and 0.7 ms.

**(3 marks)**

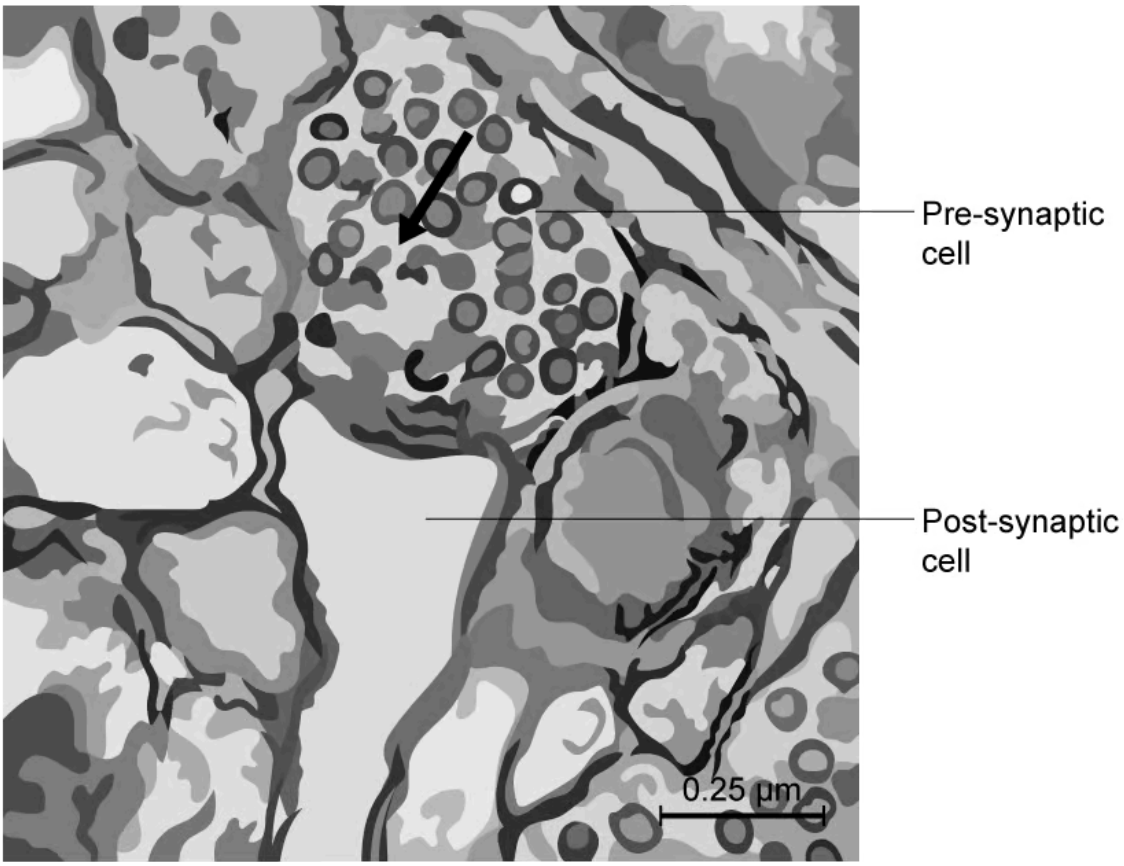
**(c)** During an action potential, the membrane potential of the axon reaches +40 mV and then falls steeply. Use the information from the graph in part (b) to explain this fall.

**(3 marks)**

**(d)** After exercise, ATP is required for the resting potential to be re-established in axons. Explain how this occurs.

**(2 marks)**

**3 (a)** Below is a micrograph of a synapse. The arrow shows the direction of the nerve impulse.




Label on the diagram the synaptic vesicles and the synaptic cleft.

**(2 marks)**

**(b)** Neonicotinoids are synthetic chemicals that bind to acetylcholine receptors in cholinergic synapses in insects. The enzyme acetylcholinesterase does not break down neonicotinoids and therefore the binding of neonicotinoids is irreversible.

Describe how this may lead to death of the insect affected by neonicotinoids.

**(3 marks)**

**(c)** Dopamine is a neurotransmitter that plays a vital role in areas of the brain responsible for muscle control. It is transported back out of the synaptic cleft by a transporter protein located within the presynaptic membrane. Dopamine diffuses across the synaptic gap and binds to a receptor on the postsynaptic membrane.

Describe how this results in the depolarisation of the postsynaptic membrane.

.....

.....

**(2 marks)**

**(d)** Explain why it is essential that neurotransmitters like dopamine are transported back out of synapses.

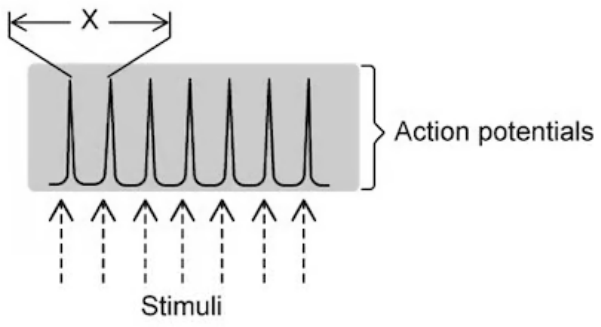
.....

.....

**(2 marks)**

**4 (a)** Researchers were studying the effect of different stimulation frequencies on the production of action potentials by a single neurone.

The diagram below shows a recording of the action potentials generated when the frequency of stimulation was 155 per second. At this specific frequency, each stimulus is able to produce one action potential.




The time required for the completion of one action potential is **X**.

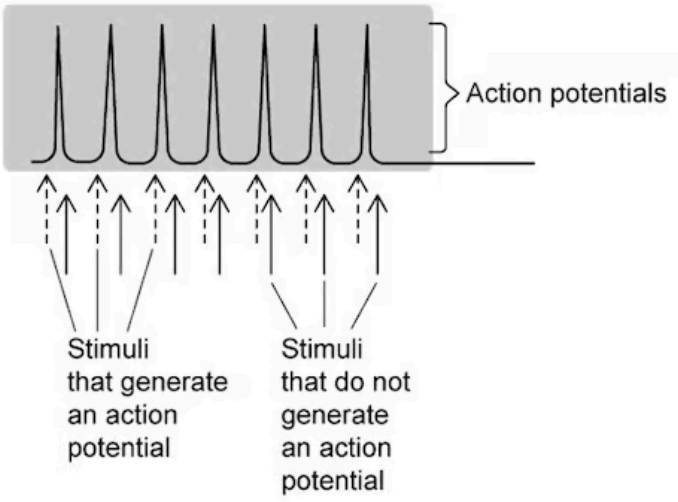
Calculate the value of **X**. Give your answer to the nearest microsecond. Show your working.

.....

.....

**(2 marks)**

**(b)** The diagram below shows the results when the stimulation frequency was 220 per second.




Not every stimulus generated an action potential.

Explain why.

.....

.....

.....

**(3 marks)**

**(c)** The following statements are about events that happen during an action potential.

**A** Hyperpolarisation of the membrane occurs
**B** Potassium ions diffuse out of the membrane of the neurone
**C** Active transport of sodium ions and potassium ions restores resting potential
**D** Sodium ion channels open
**E** Potassium ion channels open
**F** Sodium ions diffuse into the neurone

Which of the events, **A** - **F**, starts depolarisation?

.....

**(1 mark)**

**(d)** Which of the events from part (c) requires hydrolysis of ATP?

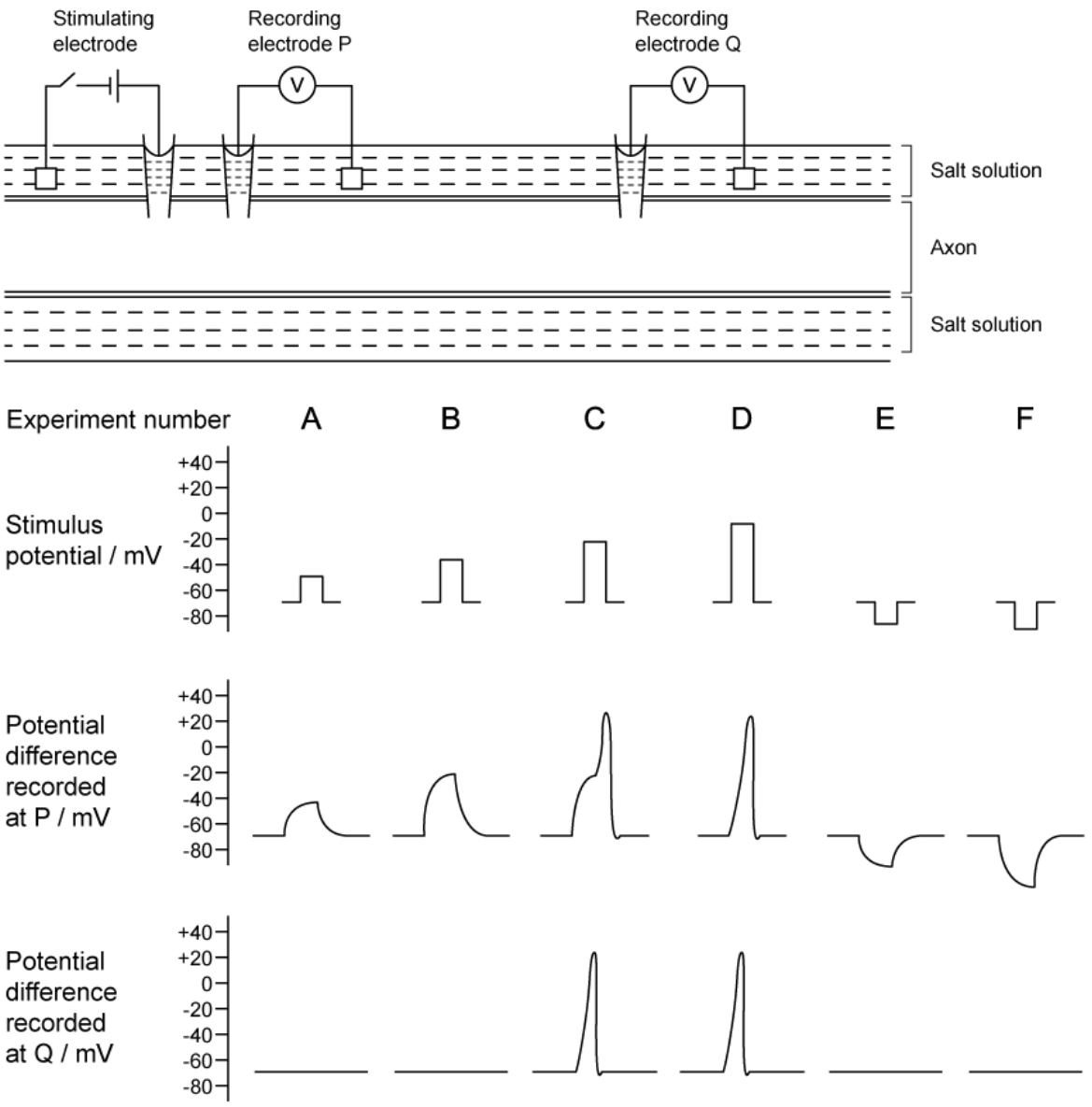
.....

**(1 mark)**

**5 (a)** Describe the mechanism which allows information to pass across a synapse.

**(5 marks)**

**(b)** Scientists wanted to investigate how a stimulating electrode changed the potential difference across an axon membrane. The scientists inserted two other electrodes, P and Q, to record any potential difference produced. The experiment was repeated six times (**A** - **F**), using a different stimulus potential each time. The diagram below shows their results.




Explain the results of experiments **A** - **D.**

**(4 marks)**

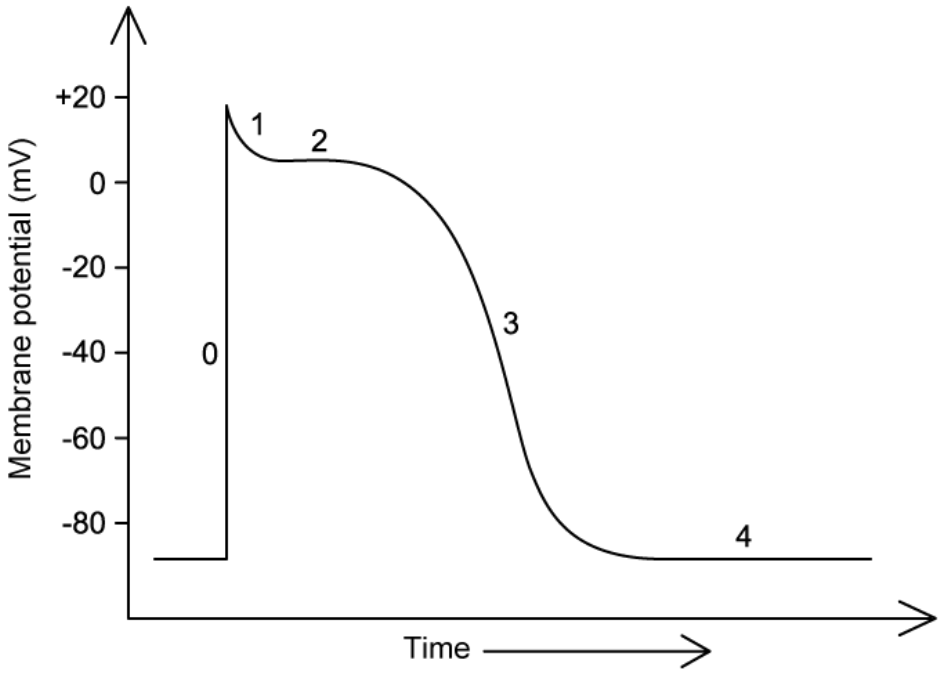
**(c)** The propagation of nerve impulses is the result of local currents within the axon.

Explain how local currents are generated and how this leads to the propagation of a nerve impulse.

**(6 marks)**

# Hard Questions

**1 (a)** The graph below shows the changes in membrane potential that occur during a cardiac (heart) action potential.




Stage 0 occurs more quickly in a cardiac action potential than the equivalent stage in a regular action potential.

Suggest **two** possible explanations for the increased rate at which stage 0 takes place in a cardiac action potential.

.....

.....

**(2 marks)**

**(b)** Compare and contrast the changes in membrane potential that occur during the cardiac action potential in part a) with the changes that occur during a regular action potential.

*Note that no credit will be given for describing the difference already noted in part a).*

.....

**(4 marks)**

**(c)** A group of heart conditions known as arrhythmias involves problems with the co-ordination or speed of the heart beat. Potassium channel blockers are a group of drugs used to treat some types of arrhythmia.

(i) Sketch on the graph in part a) the effect that you would expect a potassium channel blocker to have on the cardiac action potential.

[1]

(ii) Suggest how potassium channel blockers have the effect predicted in part i).

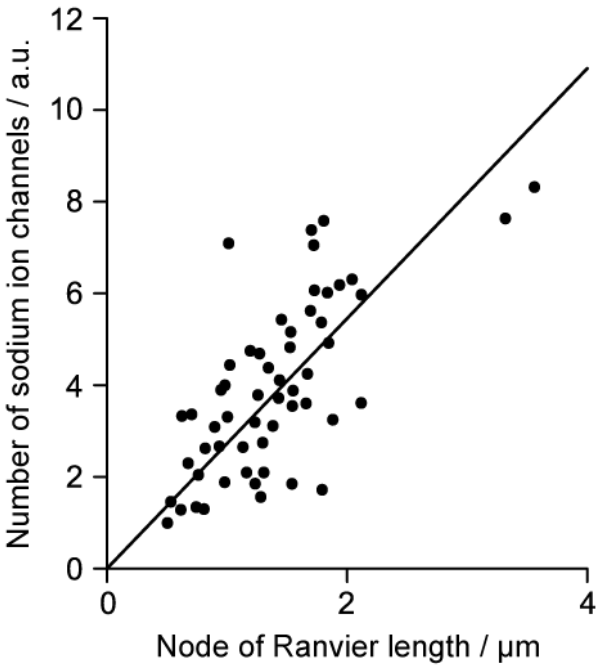
[2]

**(3 marks)**

**(d)** Suggest, with a reason, the type of arrhythmia that potassium channel blockers might be used to treat.

**(2 marks)**

**2 (a)** A study was carried out into the impact of a node of Ranvier length on nerve transmission. The graph below shows the relationship between the node of Ranvier length and the number of sodium ion channels at each node.




A student concluded from the graph that there will be more sodium ion channels at longer nodes of Ranvier.

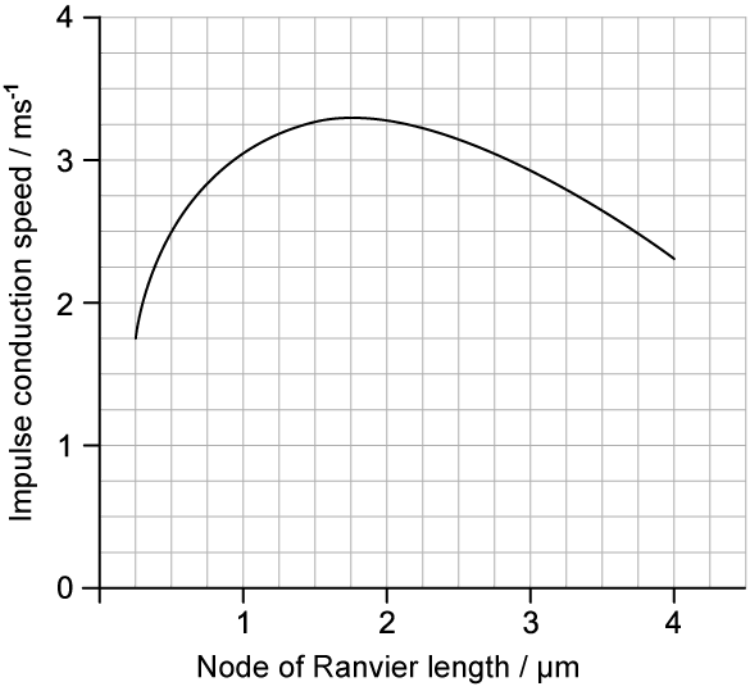
Evaluate the student's conclusion.

.....

.....

**(2 marks)**

**(b)** The study also looked at the impact of node of Ranvier length on the speed of impulse conduction in axons. The graph below shows some of the results.




Calculate the percentage change in impulse conduction speed when the node of Ranvier length increases from 0.5 µm to 1.5 µm.

**(2 marks)**

**(c)** Suggest an explanation for the change in conduction speed for nodes of Ranvier lengths between 0.25 and 1.75 µm.

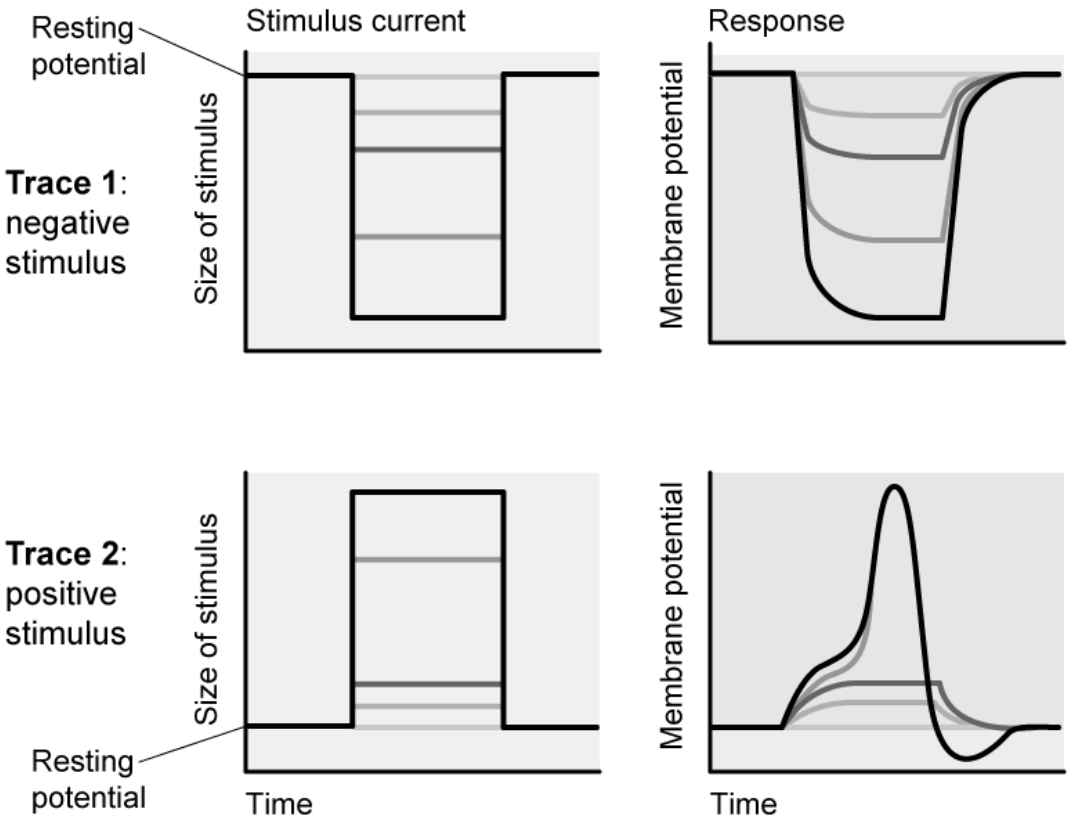
**(3 marks)**

**(d)** The study looked at nodes of Ranvier length in mice and found that an individual mouse could have some axons with longer nodes of Ranvier and some axons with short nodes of Ranvier.

Suggest why it might be advantageous to have axons with varying nodes of Ranvier length.

**(2 marks)**

**3 (a)** The graphs below show the effect of applying different electrical stimuli to a neurone on its membrane potential.



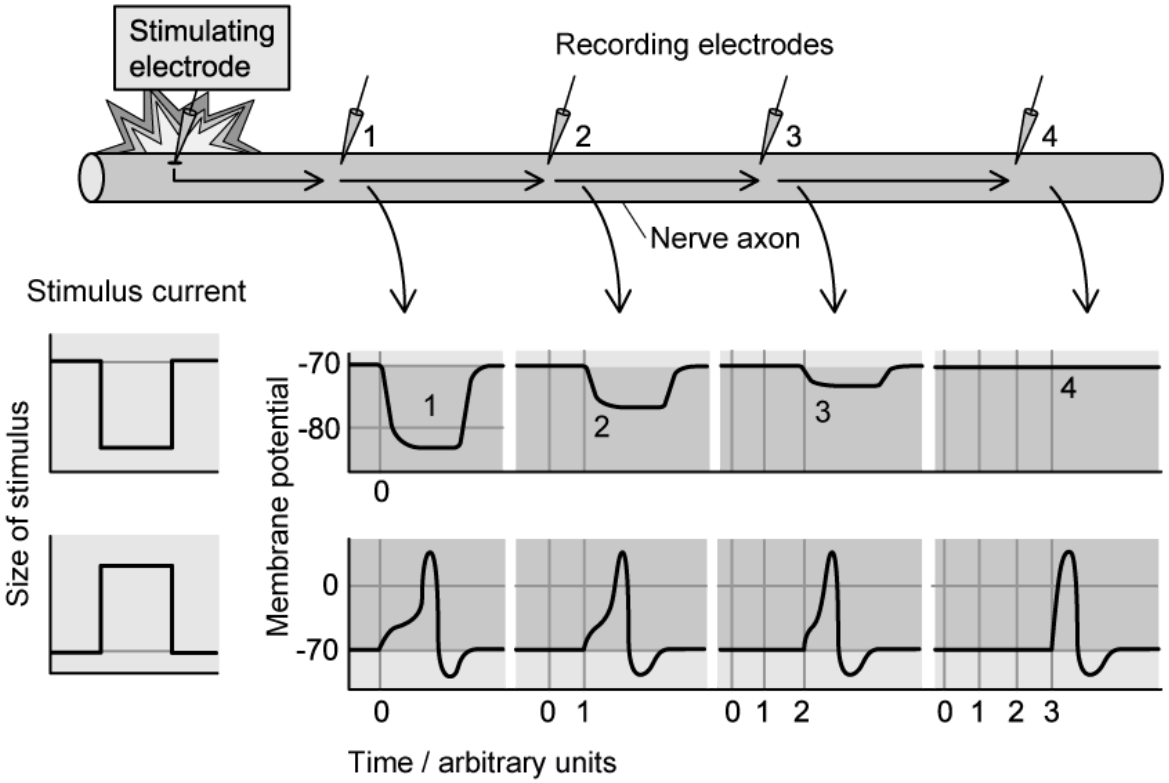

Compare and contrast the response of the membrane to the negative stimulus in trace 1 and the positive stimulus in trace 2.

**(3 marks)**

**(b)** Suggest an explanation for the changes in membrane potential shown in trace 1 in part a).

**(2 marks)**

**(c)** The graphs below shows the effect of changing the type of stimulus on the propagation of a nerve impulse along an unmyelinated axon.




Suggest an explanation for the difference between the transmission of the impulses shown in the top and bottom graphs.

.....

.....

**(2 marks)**

**(d)** In an extension to the investigation shown in part c), electrodes were inserted into a fully myelinated axon of the same diameter before applying a positive stimulus at the stimulating electrode. Electrodes 1, 2, and 4 were inserted into sections of the axon surrounded by myelin while electrode 3 was inserted into a node of Ranvier.

Suggest, each with a reason, **two** ways in which the results would look different to those in the bottom graph shown in part c).

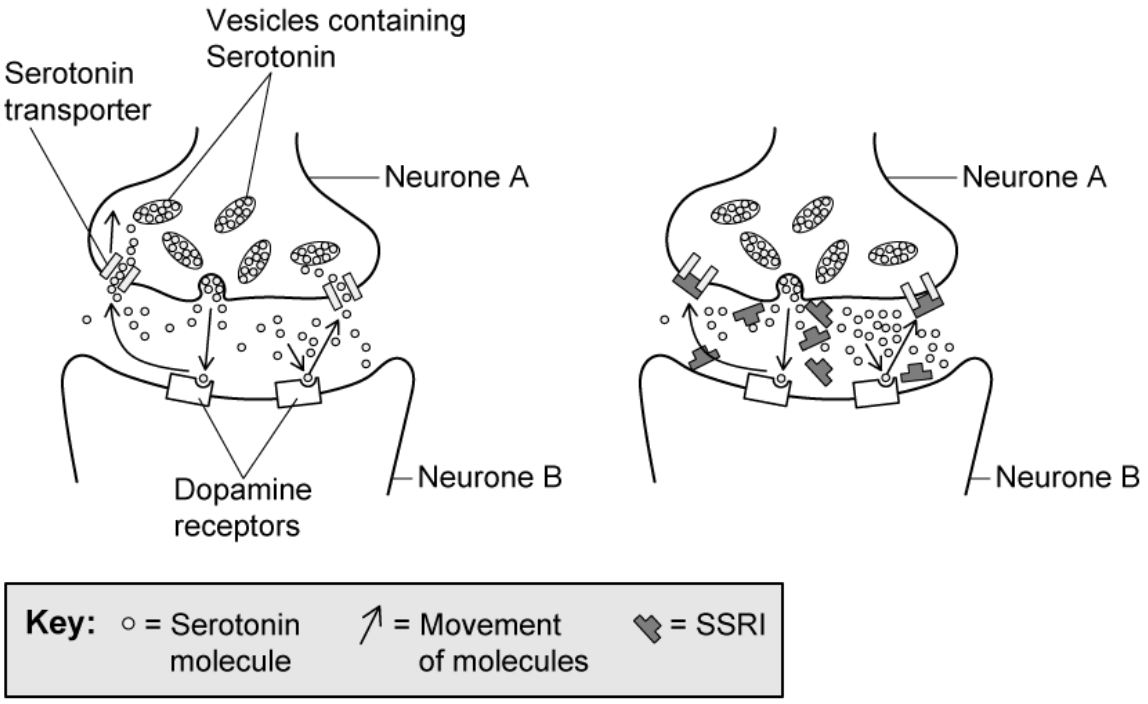
.....

.....

**(4 marks)**

**4 (a)** Serotonin is a neurotransmitter found in the brain. Low serotonin levels are thought to contribute to symptoms of clinical depression. One commonly used treatment for depression involves a group of drugs called SSRIs.

The diagram below shows a serotonin synapse in the brain both before (left) and after (right) treatment with SSRIs.




Suggest how SSRIs might be effective at treating the symptoms of depression.

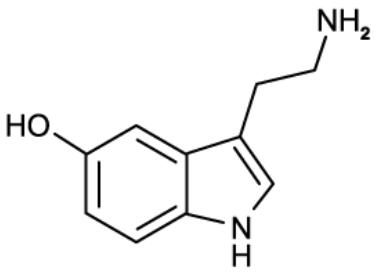
.....

.....

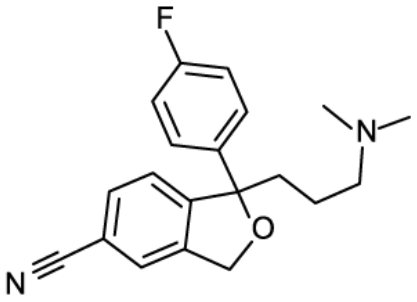
.....

**(3 marks)**

**(b)** The image below shows the chemical structures of serotonin and an SSRI called Citalopram. Citalopram is commonly prescribed for depression due to its limited side effects, but it does sometimes cause some nausea and sleep disturbance during the first few weeks.




Serotonin




Citalopram

Use the image to suggest how Citalopram can have the effect shown in part a) while also having some side effects.

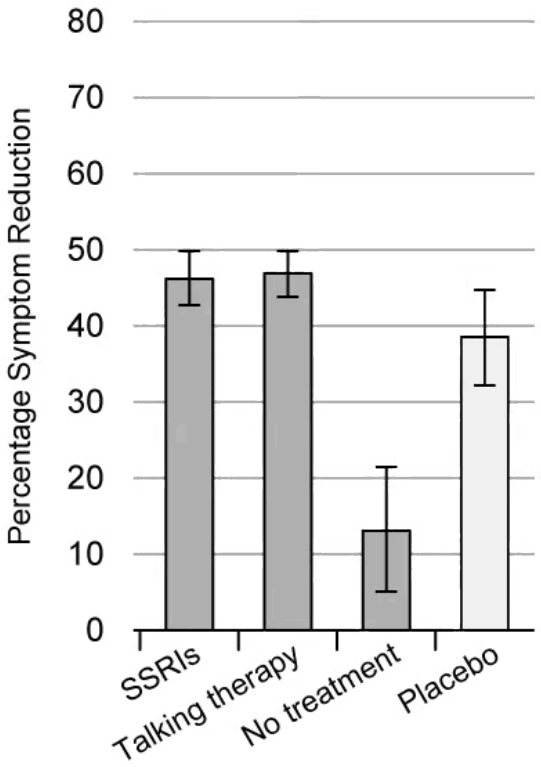
.....

.....

.....

**(3 marks)**

**(c)** Although the use of SSRIs has increased significantly in recent years there is still controversy over their effectiveness in the treatment of depression, along with some concern surrounding withdrawal symptoms at the end of treatment. One group of researchers analysed the results of around 300 studies involving treatment for depression; some of their results are shown in the graph below.




The placebo in this case was a pill identical in appearance to an SSRI but containing no active chemical ingredients.

Suggest the role of a placebo in a study of this type.

.....

.....

**(2 marks)**

**(d)** State what can be concluded about the effectiveness of SSRIs in the treatment of depression from the information provided in part c). Note that the error bars in the graph represent standard deviation.

.....

.....

.....

**(3 marks)**

**5 (a)** Draw an annotated diagram of an oscilloscope trace of an action potential.

**(5 marks)**

**(b)** Describe how a nerve impulse is transmitted from one neurone to another.

**(8 marks)**