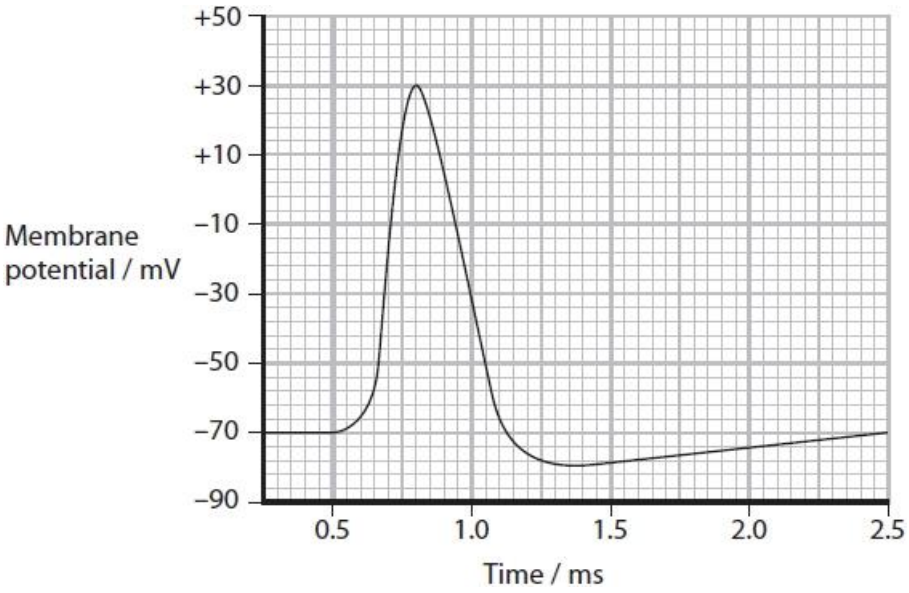
Questions

Q1.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The speed of a nerve impulse along a neurone depends on the diameter and the presence or absence of myelin.

The graph shows an action potential in a neurone.



When are voltage-gated sodium channels open?

(1)

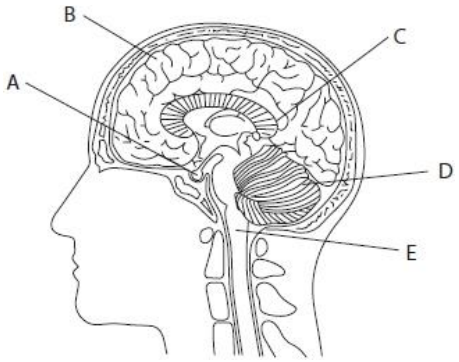
- ☒ **A** 0.25 ms
- ☒ **B** 0.75 ms
- ☒ **C** 1.00 ms
- ☒ **D** 1.25 ms

(Total for question = 1 mark)

Q2.

The human brain controls many functions.

The diagram shows a section through a human brain with parts labelled A to E.



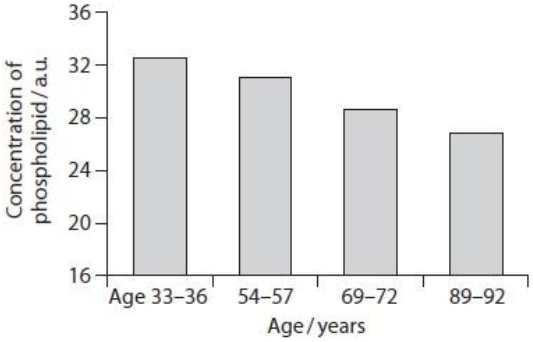
The human brain consists of 100 billion neurones.

The function of these neurones is affected by many factors.

The concentration of phospholipid in neurones from one part of the brain was measured.

This was carried out in people from different age ranges.

The graph shows the results.



Explain how age might affect the structure of a neurone and the speed of transmission of an impulse.

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(Total for question = 3 marks)

Q3.

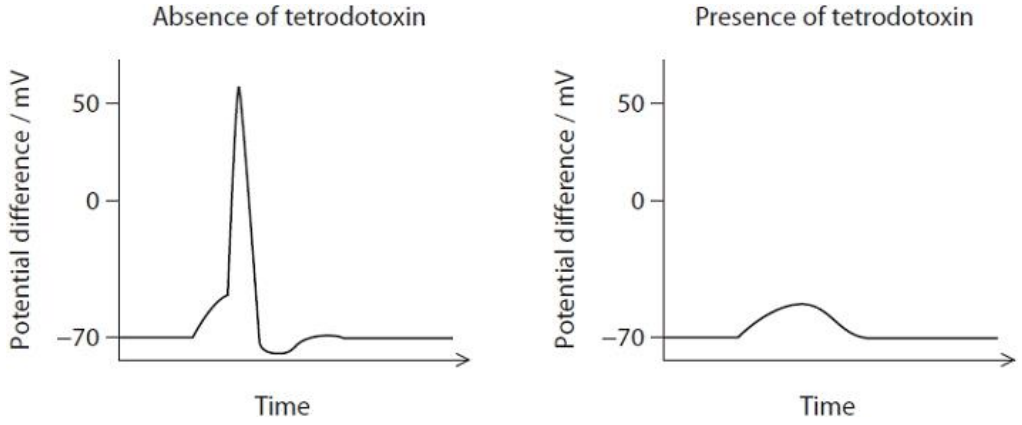
The photograph shows a blue-ringed octopus.

This octopus produces tetrodotoxin that it uses to paralyse its prey.

The effects of tetrodotoxin on a neurone were investigated.

A neurone was stimulated in the absence of and in the presence of tetrodotoxin.

The graphs show the results of this investigation.



Comment on how tetrodotoxin affects the potential difference of a neurone when the prey of the octopus is paralysed.

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(Total for question = 4 marks)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Acetylcholine is a neurotransmitter released by neurones in the autonomic nervous system.

(i) Which of the following substances bind to acetylcholine receptors?

(1)

1. cobra venom
2. nicotine
3. lidocaine

☐ **A** 1 and 2
☐ **B** 1 and 3
☐ **C** 1, 2 and 3
☐ **D** 2 and 3

(ii) Which row is correct for acetylcholine?

(1)

	Type of neurone that releases acetylcholine	Effect of acetylcholine
☐ **A**	parasympathetic neurone	increases heart rate
☐ **B**	parasympathetic neurone	decreases heart rate
☐ **C**	sympathetic neurone	increases heart rate
☐ **D**	sympathetic neurone	decreases heart rate

(iii) Describe the events that lead to the release of acetylcholine at a synapse.

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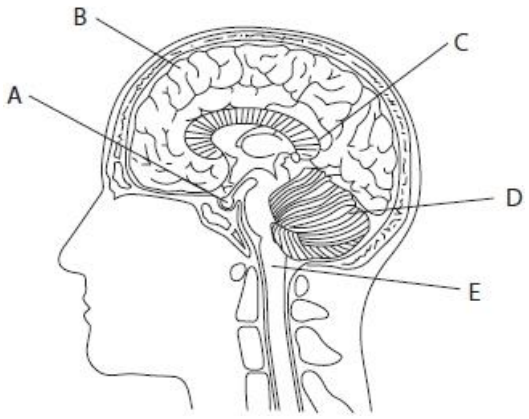
(Total for question = 5 marks)

Q5.

The human brain controls many functions.

The diagram shows a section through a human brain with parts labelled A to E.



Poisons can also affect the function of neurones in the brain.

The photograph shows a pufferfish, a traditional food delicacy in Japan.

Pufferfish have to be carefully prepared by a chef to remove a poison called tetrodotoxin. This poison causes muscle paralysis.

Neurones were placed in a solution containing tetrodotoxin and in a control solution.

The neurones were stimulated and the potential difference across the axon membrane was measured.

The table shows the results.

Solution	Potential difference after stimulation / mV
tetrodotoxin	−70
control	+40

Analyse the data to explain the effect of tetrodotoxin on the neurone.

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(Total for question = 4 marks)

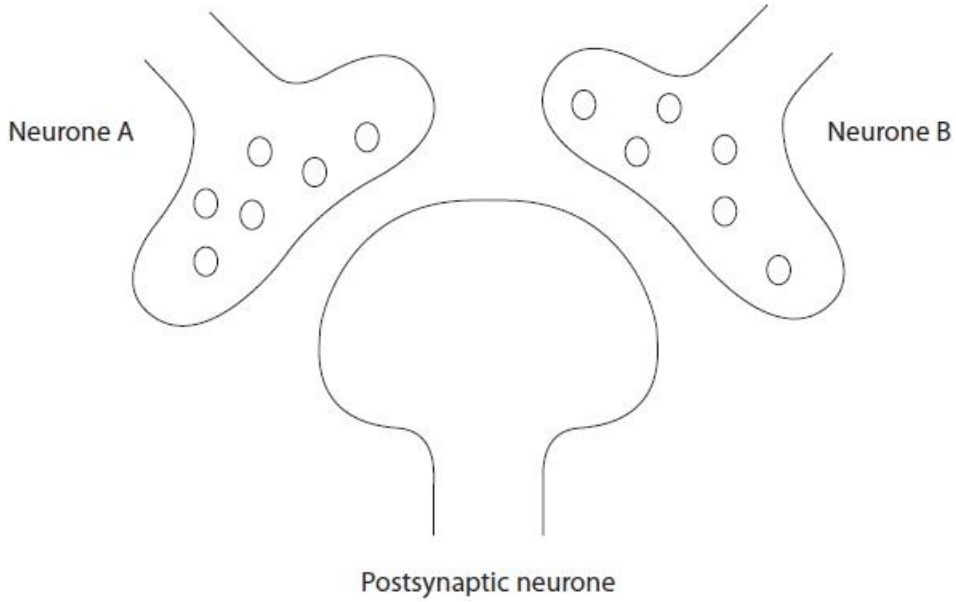
Q6.

The diagram shows the structure of a synaptic junction between three neurones.

Neurone A releases the excitatory neurotransmitter acetylcholine.

Neurone B releases the inhibitory neurotransmitter glutamate.

Glutamate causes chloride ions to move into the postsynaptic neurone.



(i) Describe the sequence of events that leads to an excitatory postsynaptic potential (EPSP) in the postsynaptic neurone after stimulation of neurone A.

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(ii) Which of the following rows correctly describes the action of each substance on this postsynaptic neurone?

(1)

	Nicotine	Lidocaine	Cobra venom
☒ **A**	excitatory	excitatory	excitatory
☒ **B**	excitatory	inhibitory	inhibitory
☒ **C**	inhibitory	excitatory	excitatory
☒ **D**	inhibitory	inhibitory	inhibitory

(Total for question = 5 marks)

Q7.

Explain how the resting potential is maintained in a neurone.

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(Total for question = 4 marks)

Q8.

Acetylcholine is a neurotransmitter produced by the parasympathetic nervous system.

Describe the process by which acetylcholine is released from a synapse.

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(Total for question = 4 marks)

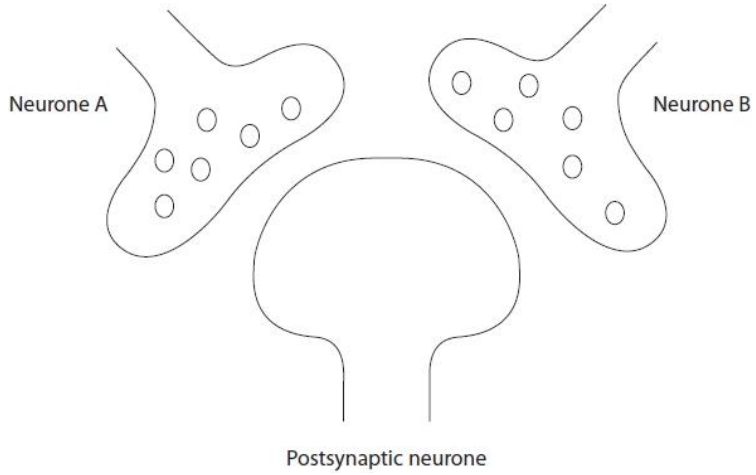
Q9.

The diagram shows the structure of a synaptic junction between three neurones.

Neurone A releases the excitatory neurotransmitter acetylcholine.

Neurone B releases the inhibitory neurotransmitter glutamate.

Glutamate causes chloride ions to move into the postsynaptic neurone.



A scientist investigated the effect of the intensity of stimulation of neurones A and B on the production of an action potential in the postsynaptic neurone.

High intensity stimulation of neurones A and B causes a high frequency of impulses to arrive at the presynaptic terminals.

The results are shown in the table.

Intensity of stimulation		Production of action potential in postsynaptic neurone
Neurone A	Neurone B	
low	low	no
low	high	no
high	low	yes
high	high	yes

Explain the effect of the intensity of stimulation on the production of an action potential in the postsynaptic neurone.

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(Total for question = 3 marks)

Q10.

Scientists investigated the effect of stimulating an axon with different voltages and measured the response.

The table shows the results of this investigation.

Stimulus voltage / mV	Response
25	No action potential
35	No action potential
45	No action potential
55	Action potential
65	Action potential
75	Action potential

Analyse the data to describe the conclusions which can be drawn.

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(Total for question = 2 marks)

Q11.

The brain is involved in many homeostatic mechanisms.

An action potential results from the depolarisation of the membrane of a neurone.

Which row of the table shows the correct state of the ion channels during this depolarisation?

(1)

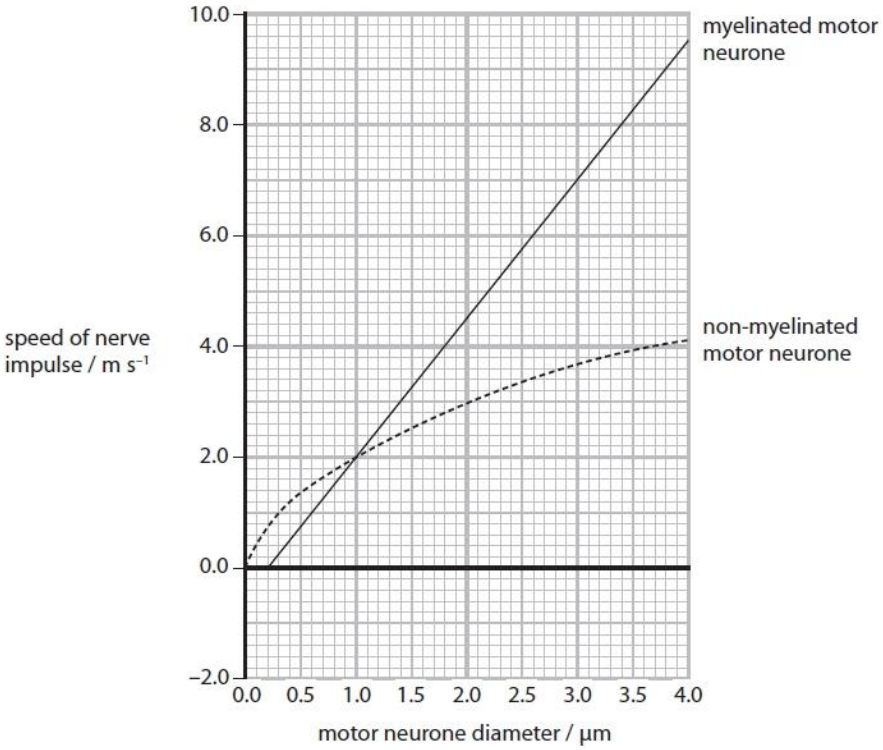
	Na^+ channels	K^+ channels
☒ **A**	closed	closed
☒ **B**	closed	open
☒ **C**	open	closed
☒ **D**	open	open

(Total for question = 1 mark)

Q12.

The speed of a nerve impulse along a neurone depends on the diameter and the presence or absence of myelin.

The graph shows the relationship between the diameter of the neurone and the speed of nerve impulses along myelinated and non-myelinated motor neurones.



(i) Compare and contrast the effect of diameter on the speed of an impulse in myelinated and non-myelinated motor neurones.

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(ii) Determine the speed of a nerve impulse along a myelinated motor neurone with a diameter of 5 μm.

The equation for a linear relationship is $y = mx + c$

(3)

Answer .....

(iii) Multiple sclerosis (MS) is a disease that results in the loss of myelin around motor neurones.

Explain why the speed of nerve impulses along axons is slower in people with MS.

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(Total for question = 10 marks)

Q13.

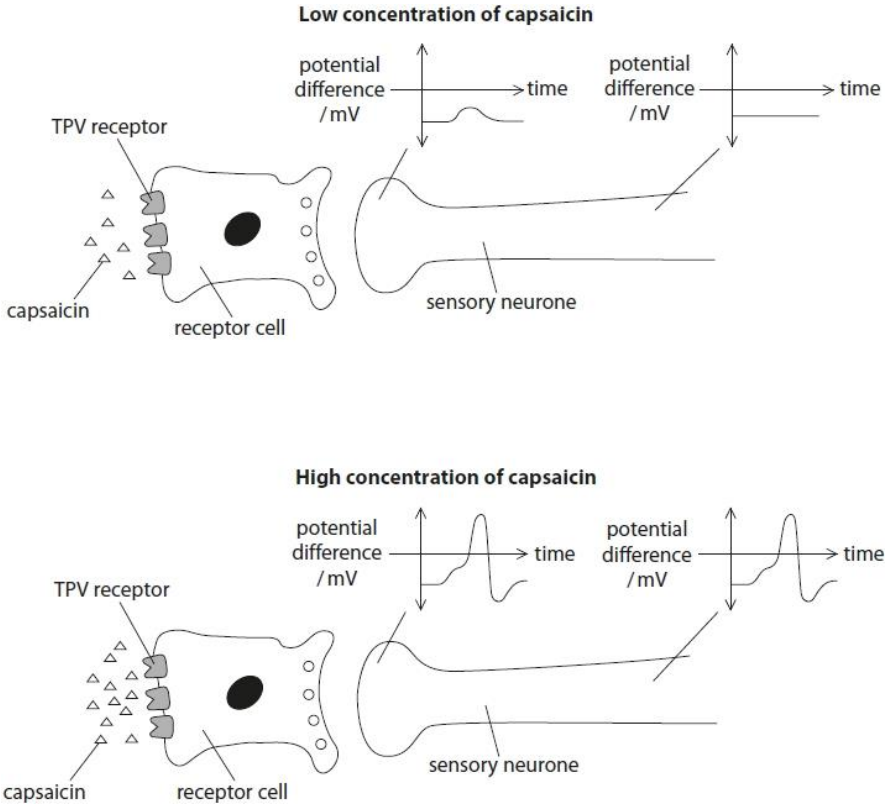
Acetylcholine is a neurotransmitter released by neurones in the autonomic nervous system.

Capsaicin is a substance found in chilli plants that makes them taste 'hot.'

Capsaicin binds to temperature receptor proteins called TPV receptors. This stimulates impulses along sensory neurones that send impulses to the brain.

The effect of capsaicin on the depolarisation of the membrane of a sensory neurone was investigated. The potential difference across the membrane was measured at two places on the sensory neurone after adding capsaicin.

The results for a high concentration and a low concentration of capsaicin are shown in the diagram.



(i) Explain the effect of capsaicin on the depolarisation of the sensory neurone.

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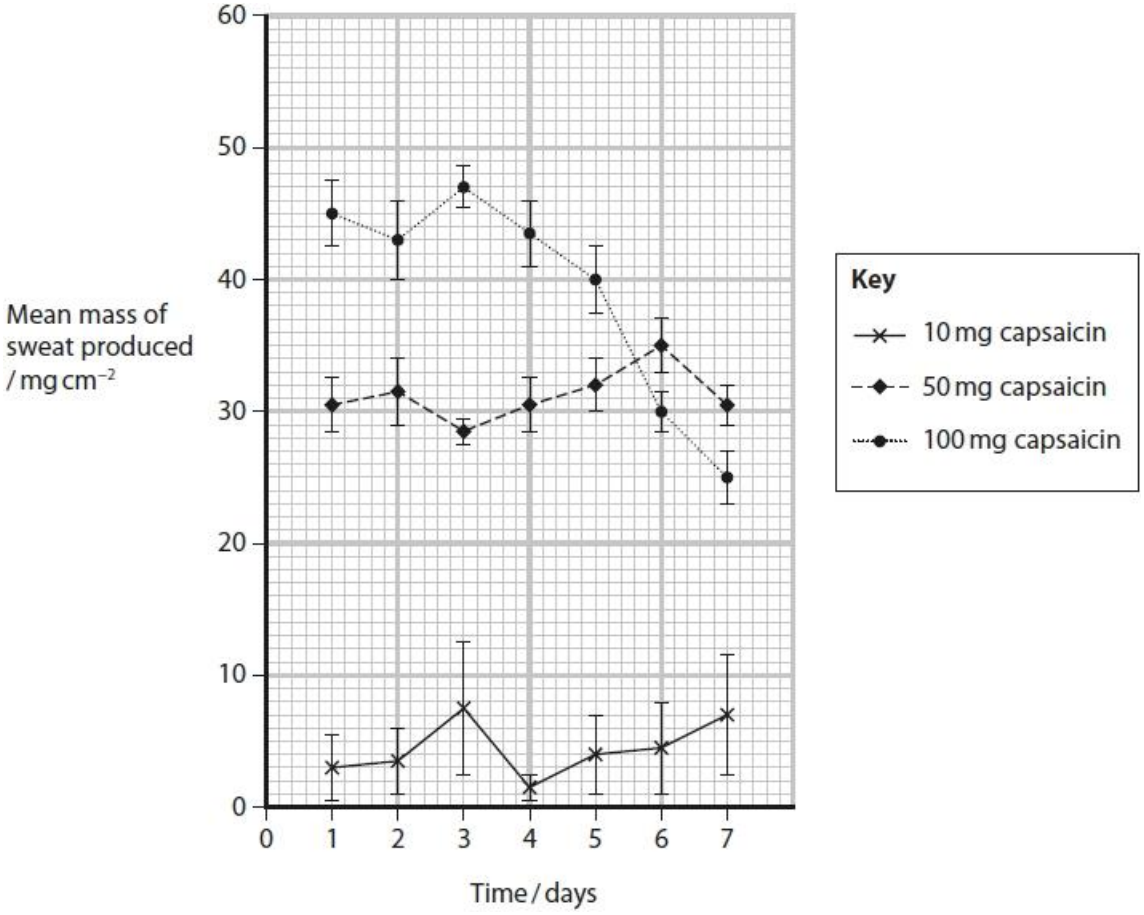
*(ii) Capsaicin affects sweat production. It has been suggested that capsaicin could be used to lower the temperature of people with fevers.

The effect of three different doses of capsaicin on sweat production was investigated.
Five students took one 10 mg tablet of capsaicin each day, for one week.
The mass of sweat produced from a 10 cm^2 area of skin was measured one hour after taking each tablet of capsaicin.
The mean mass of sweat per square centimetre of skin for the group of students was calculated for each day.
This was repeated with different groups of students taking 50 mg of capsaicin and taking 100 mg of capsaicin.
Most of the students who were given 100 mg of capsaicin reported a burning sensation and redness of the skin.
The results are shown in the graph.
Error bars represent standard deviations.



Analyse the data to discuss the use of capsaicin to lower the temperature of people with fevers.

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(Total for question = 9 marks)

Q14.

Nerve impulses are transmitted along neurones.

(i) In the time period between two nerve impulses, the potential difference across the membrane is –70 mV.

State the term given to this potential difference.

(1)

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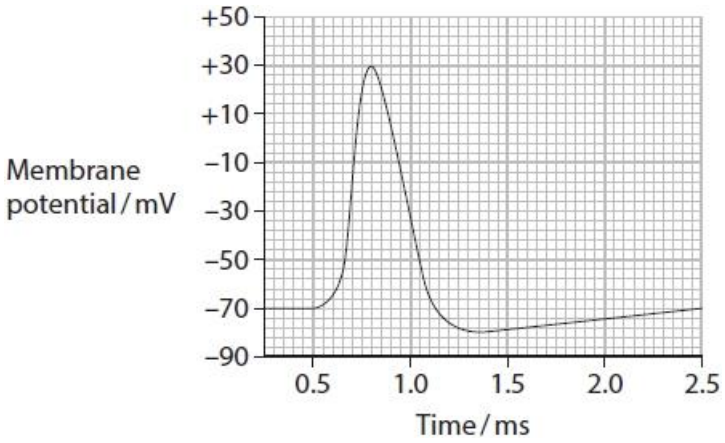
(ii) When the neurone is stimulated, an action potential may occur in the axon, due to the change in permeability of the membrane to ions.

The graph shows an action potential.



Describe what happens in the axon membrane to cause the change in potential difference
between 0.55 ms and 0.80 ms.

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(Total for question = 5 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	B 0.75 ms A is incorrect because at 0.5s it is a resting potential C is incorrect because sodium channels are closed D is incorrect because sodium channels are closed		1

Q2.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • slows {transmission / impulse} (1) • because reduced {myelin sheath / Schwann cells} (1) • affects saltatory conduction / affects jumping between nodes of Ranvier (1) • (change to membrane) affects action potential / ion movement / ion channels (1)		(3)

Q3.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to four of the following: • change in {potential difference} in tetrodotoxin is small(er) / (1) • no action potential / less depolarisation (1) • (voltage gated) sodium channels {not open / closed / blocked} (1) • sodium (ions) cannot pass through membrane / sodium (ions) cannot enter neurone (1) • no nerve impulse to muscles / muscles not stimulated / muscles cannot contract (1)	**ACCEPT** no depolarisation **ACCEPT** less sodium ions enter **ACCEPT** effector for muscle	**4**

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	**A** 1 and 2 *B is incorrect because lidocaine binds to voltage gated sodiumchannels* *C is incorrect because lidocaine binds to voltage gated sodiumchannels* *D is incorrect because lidocaine binds to voltage gated sodiumchannels*		**1**
(ii)	B parasympathetic neurone reduce *A is incorrect because acetylcholine reduces the heartrate* *C is incorrect because acetylcholine is released byparasympathetic neurones* *D is incorrect because acetylcholine is released byparasympathetic neurones*		**1**
(iii)	An answer that makes reference to three from: • action potential / impulse arrives at pre-synaptic {terminal / knob}(1) • calcium channels open and calcium ions diffuse in(1) • vesicles move to membrane (1) • vesicles fuse with membrane and release acetylcholine (1)	**Allow** action potential stimulatespresynaptic membrane **Allow** Ca^{2+} **Allow** exocytosis	**3**

Q5.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • neurone at resting potential (1) • because (voltage gated) sodium (ion) channels {closed / blocked} (1) • therefore no movement of sodium (ions) into neurone / into cell / into axon / across membrane (1) • therefore prevents {depolarisation / action potential} (1)	**ACCEPT** not open **DO NOT ACCEPT** nerve	(4)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to four of the following: • arrival of {action potential / impulse} at presynaptic {knob / terminal} (1) • calcium channels open / calcium ions enter (presynaptic knob) (1) • vesicles {move to / fuse with} presynaptic membrane (1) • acetylcholine {diffuses across / released into} the {synapse / cleft} (1) • binding to receptors on postsynaptic membrane {opening sodium channels / allowing sodium ions to enter} (1)	**Accept** calcium ions pass through membrane **Do not accept** calcium ions enter membrane **Accept** neurotransmitters for acetylcholine	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	The only correct answer is **B** (excitatory, inhibitory, inhibitory) **A** is not correct because lidocaine is inhibitory affecting the Na^+/K^+ ATPase pump, and cobra venom is inhibitory, blocking acetylcholine receptors **C** is not correct because nicotine is excitatory, mimicking acetylcholine, lidocaine is inhibitory affecting the Na^+/K^+ ATPase pump, and cobra venom is inhibitory, blocking acetylcholine receptors **D** is not correct because nicotine is excitatory, mimicking acetylcholine		**(1)**

Q7.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to four of the following: • sodium potassium pump (1) • therefore sodium (ions) move out and potassium (ions) move in (1) • potassium (ions) move out through potassium channels (1) • sodium channels close / membrane is impermeable to sodium (ions) / sodium (ions) do not move in (1) • outside more positive than inside (1)	**ACCEPT** Na^+ for sodium ions and K^+ for potassium ions **DO NOT ACCEPT** potassium channels are open so potassium ions enter **ACCEPT** only a few sodium channels are open / only a few sodium ions move in **ACCEPT** outside becomes positive **AND** inside becomes negative	**4**

Q8.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: • {action potential / impulse} arrives at (presynaptic) terminal / membrane / synaptic knob (1) • calcium channels open (1) • calcium ions diffuse into the neurone (1) • vesicles move towards the (presynaptic) membrane (1) • vesicles fuse with presynaptic membrane / exocytosis occurs (1)		4

Q9.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • an action potential only occurs {when stimulation of A is high and B is low / when threshold is reached} (1) • because the levels of acetylcholine are high and the levels of glutamate are low (1) • an action potential does not occur when levels of glutamate are high (1) • because movement of chloride ions causes {hyperpolarisation / reduces depolarisation} (1)	**Accept** EPSP is greater than IPSP **Accept** because enough sodium ions enter the neurone / enough sodium channels open **Accept** excitatory transmitter for acetylcholine **Accept** IPSP is greater than EPSP **Accept** inhibitory transmitter for glutamate **Accept** description of hyperpolarisation e.g. inside becomes more negative	(3)

Q10.

Question Number	Answer	Additional Guidance	Mark
	An answer that includes the following • there is no action potential until the stimulus is greater than 45 (mV) (1) • this is the threshold value (1)	Accept range between 45-55 mV / 46 -55mV Accept converse Accept this is where depolarisation occurs / Na channels open Ignore optimum voltage	Exp (2)

Q11.

Question Number	Answer	Additional Guidance	Mark
	The only correct answer is **C** (open, closed) **A** is not correct because Na^+ channels are open not closed **B** is not correct because Na^+ channels are open, not closed and K^+ channels are closed not open **D** is not correct because K^+ channels are closed not open		(1)

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to four from the following: similarity • same speed at 1 μm • speed increases for myelinated and unmyelinated axons (1) differences (max 3) • for axon diameters of more than 1 μm, myelinated are faster (1) • myelinated have a steeper / greater increase (1) • myelinated axons are slower below 1 μm in diameter (1) • myelinated is linear relationship	At least one similarity and one difference **Accept** converse **Accept** ref to numerical comparison **Accept** converse **Accept** proportional increase / **Accept** converse for non-myelinated	4

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct extrapolation to y axis to calculate c (1) • correct calculation of gradient • correct calculation of speed at 5 μm diameter (1)	-0.5 (**Accept** -0.4 to -0.6) 2/0.8 = 2.5 12 m s^{-1} (**Accept** between 11.9 and 12.1) **Accept** 12 for two marks Correct answer gains full marks	3

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to three of the following: • saltatory transmission does not occur (1) • because there are {fewer / no} nodes of Ranvier (1) • so impulse does not jump (between nodes) (1) • and sodium channels have to stimulate local current flow along each section of membrane / sodium channels have to open in every part of membrane / depolarisation has to occur along the whole length (1)		3

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three from: • capsaicin binds to (TPV) receptors in membrane of receptors cells (1) • this causes neurotransmitter (from receptors) to bereleased onto sensory neurone {generating an epsp / opening sodium channels / causing sodium ions to flow in} (1) • high concentrations of capsaicin generate an epsp that) overcomes threshold to form an {action potential} (1) • action potential moves along the neurone by (opening sodium channels) (1)	**Allow** low concentrations does notovercome threshold **Allow** high concentrations opens voltage gated sodium channels	3

Question Number	Indicative content	
(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding ofmaterial in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientificand relevant. **Descriptions** • 100 mg / 50 mg / higher doses / of capsaicin increase mass of sweat produced D • sweat production from 100 mg decreases after 5 days D • 10 mg has less effect D • 10 mg / 50mg have same effect for all seven days D • 100 mg effect decreases after 3/4/5 days D • 100 mg generates less sweat than 50 mg after 5/6 days D **Explanation / Optimal Dose** • increased sweating and evaporation of water E • evaporation of water requires heat energy E • latent heat of vaporisation is high for water so sweating removes a lot of heat energy E • 50 mg is optimal dose E • because there 100 mg begins to lose effect after 3/4/5 days E • and 100 mg produces more side effects / burning sensations / red rash E **Validity of data** • 50 mg dose has consistent sweat production as error bars all overlap V • 100 mg and 50 mg are significantly higher than 10 mg as error bars do not overlap V • 10 mg has a high variation between responses of volunteers V	**6**

	• no control experiment has been carried out V • sample size is small V • capsaicin may interfere with other medicines / may make illness worse / no tests done on illpeople V		
Level	**Marks**		
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a fewstrengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledgeand understanding but with limited evidence to support the judgement being made. **Basic description of the effects of each dose** **one mark: any one from D, E, V** **two marks: 3D, 2D + 1E, 2D + 1V**	
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengthsand weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge andunderstanding, with occasional evidence to support the judgement being made. **Detailed description and either E or V** **three marks: at least four points from D + E or D + V** **four marks: at least five points from D + E or D + V**	
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application ofrelevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge andunderstanding with evidence to support the judgement being made. **Must have elements of D, E and V.** **five marks: at least six points from D, E and V** **six marks: at least seven points from D, E and V AND must refer to standard deviations**	

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	resting (potential) (1)		**Clerical (1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer including four of the following • {sodium / Na} channels open (1) • sodium **ions** flow into {axon / cell / neurone} (1) • this causes depolarisation (1) • {sodium / Na} channels close at {0.8ms / 30mV} (1) • {potassium / K} channels open at {0.8ms / 30mV} (1)	Ignore how they are moving Accept sodium gates open Ignore membrane	**Exp (4)**