6.5 Neurones & Synapses

Question Paper

Course	DP IB Biology
Section	6. Human Physiology
Topic	6.5 Neurones & Synapses
Difficulty	Medium

Time allowed: 60

Score: /49

Percentage: /100

Question 1a

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]

Question 1b

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

Explain how.

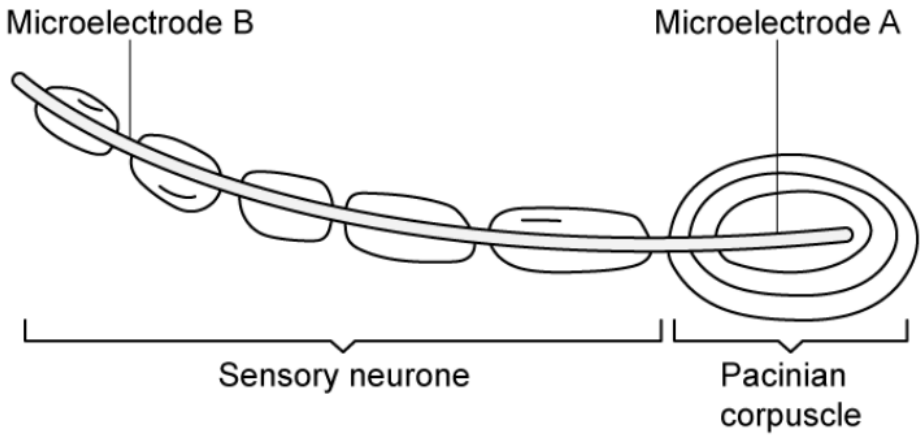
[3 marks]

Question 1c

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]

Question 1d

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]

Question 2a

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.

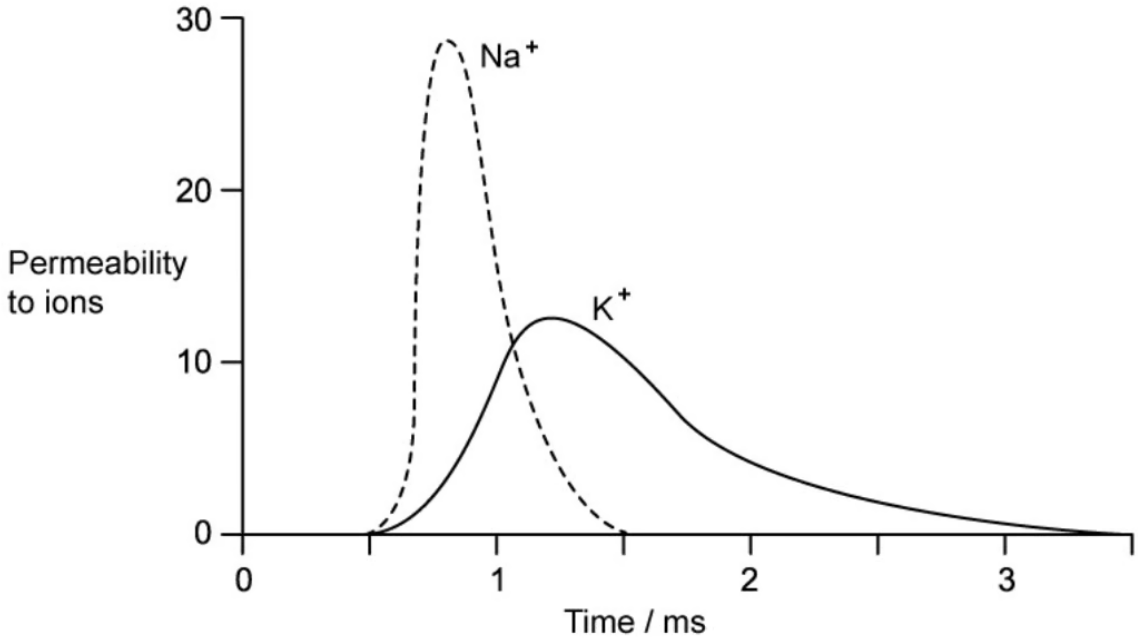
Explain how a lower temperature leads to slower nerve impulse conduction.

[2 marks]

Question 2b

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]

Question 2c

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]

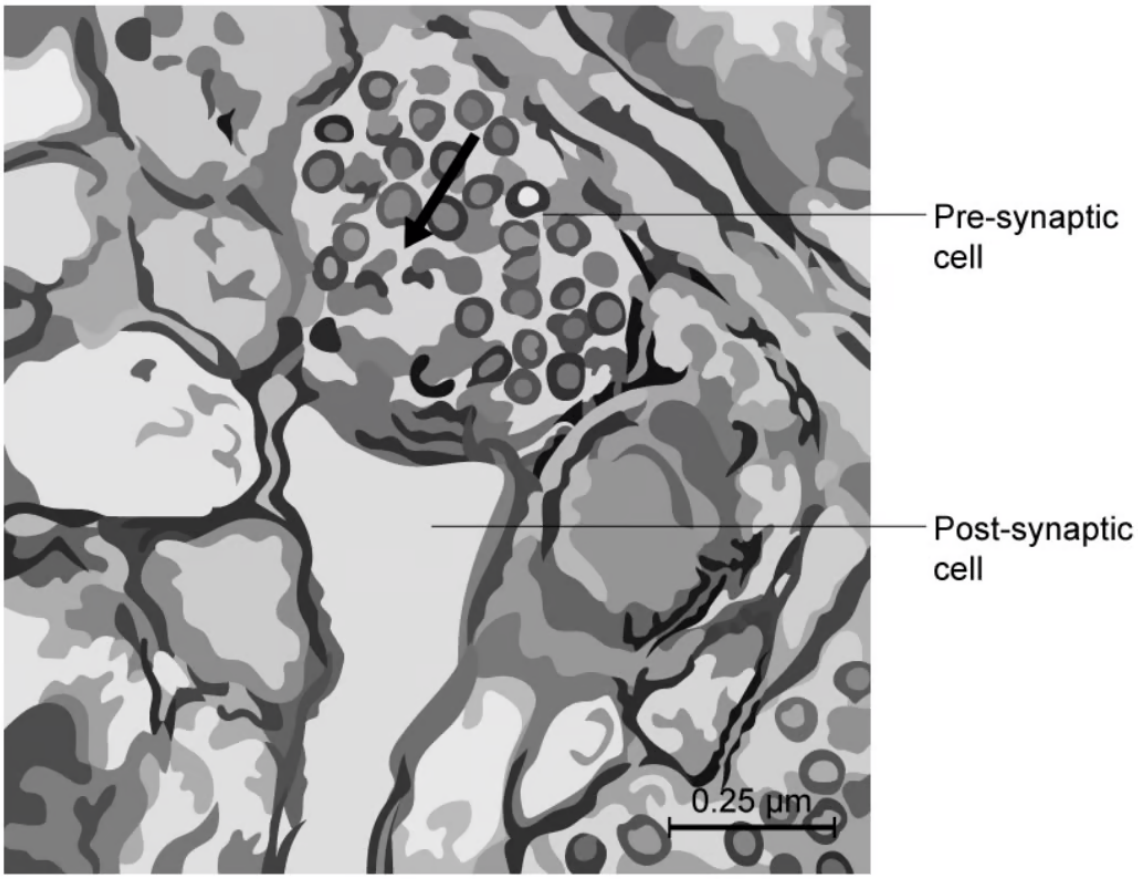
Question 2d

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

[2 marks]

Question 3a

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]

Question 3b

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]

Question 3c

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]

Question 3d

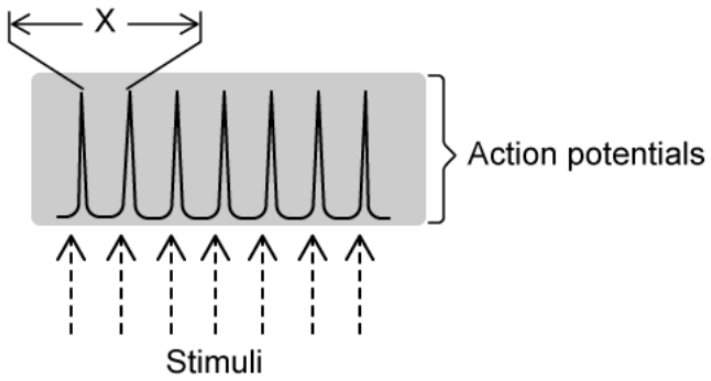
d) Explain why it is essential that neurotransmitters like dopamine are transported back out of synapses.

[2 marks]

Question 4a

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.



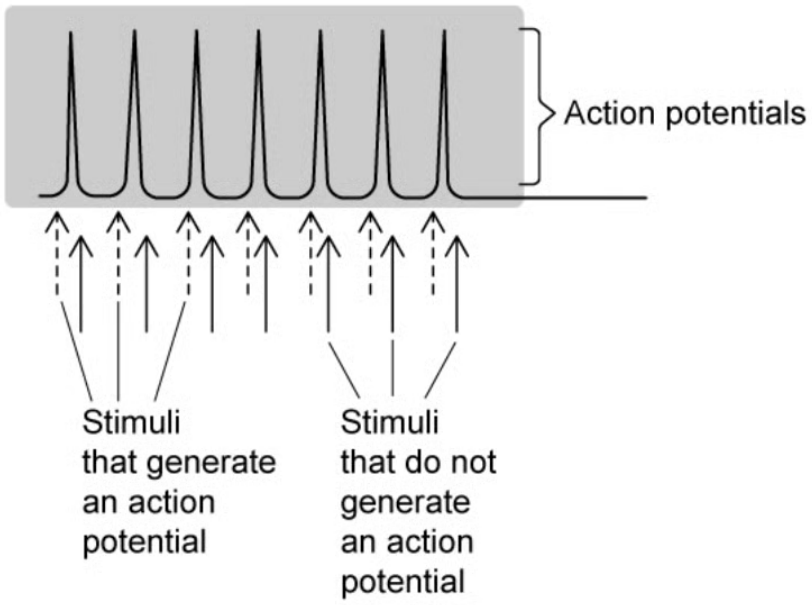
The time required for the completion of one action potential is **X**.

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

[2 marks]

Question 4b

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]

Question 4c

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]

Question 4d

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

[1 mark]

Question 5a

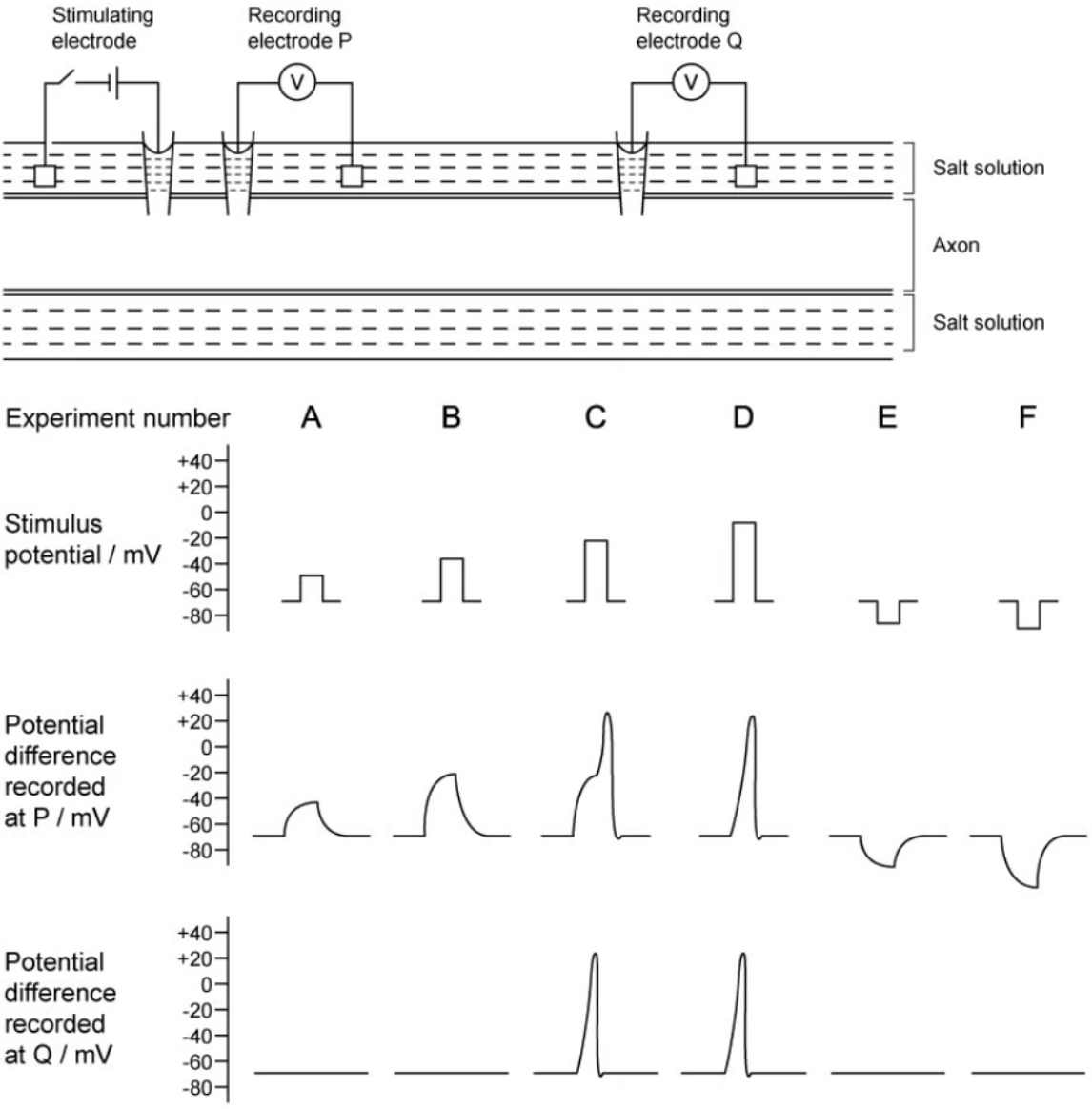
One mark is available for clarity of communication throughout this question.

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

[5 marks]

Question 5b

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]

Question 5c

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]