



Neural signalling: practice questions

8 questions • 29 marks • mark scheme at the back

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

Name

Total / 29

1 PAPER 1A STYLE [1 mark]

How does the sodium-potassium pump contribute to the resting potential of a neuron?

- A. ☐ It pumps two Na^+ out and three K^+ in by facilitated diffusion
- B. ☐ It pumps three Na^+ out and two K^+ in using energy from ATP
- C. ☐ It pumps Na^+ and K^+ into the neuron using energy from ATP
- D. ☐ It opens voltage-gated channels so Na^+ diffuses out

2 PAPER 1A STYLE [1 mark]

Why can a signal pass in only one direction across a typical synapse?

- A. ☐ The synaptic cleft is too wide for ions to diffuse back
- B. ☐ The postsynaptic neuron has no sodium-potassium pumps
- C. ☐ Only the presynaptic neuron releases neurotransmitter and only the postsynaptic membrane has its receptors
- D. ☐ Voltage-gated calcium channels are found only in the postsynaptic membrane

3 PAPER 1A STYLE [1 mark]

HL only

How does cocaine affect synaptic transmission?

- A. ☐ It binds to acetylcholine receptors and blocks transmission
- B. ☐ It stimulates exocytosis of dopamine from the presynaptic neuron
- C. ☐ It opens chloride channels in the postsynaptic membrane
- D. ☐ It blocks reuptake of dopamine into the presynaptic neuron

4

[6 marks]

The table shows the diameter and conduction speed of six nerve fibres. The values are typical values for practice. (a) Compare the conduction speeds of fibre C and fibre D. [2] (b) Calculate how many times wider fibre C is than fibre D. [1] (c) A larger study of 50 myelinated fibres found a correlation coefficient of $r = 0.95$ between diameter and conduction speed. State the type of correlation and calculate the coefficient of determination, R^2 . [2] (d) Using the data, suggest one advantage of myelination in the nervous system of a vertebrate. [1]

Diameter and conduction speed of six nerve fibres			
Fibre	Myelinated	Diameter / μm	Conduction speed / m s^{-1}
A	No	0.5	0.6
B	No	1.0	1.2
C (squid giant axon)	No	500	25
D	Yes	4	24
E	Yes	10	60
F	Yes	20	120

Answer =

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5

[4 marks]

Describe how the arrival of an action potential at a presynaptic neuron leads to an excitatory postsynaptic potential at a synapse that uses acetylcholine.

[illegible]

HL only

An oscilloscope recorded the membrane potential at one point on an axon. The table gives readings from the trace during one action potential. (a) State the resting potential of this axon. [1] (b) Explain the change in membrane potential between 1.0 ms and 1.5 ms. [2] (c) Explain the change in membrane potential between 1.5 ms and 2.5 ms. [2] (d) Another trace from the same axon showed 24 action potentials in 0.40 s. Calculate the number of impulses per second. [1]

Membrane potential during one action potential

Time / ms	Membrane potential / mV
0.0	-70
0.5	-70
1.0	-55
1.5	+30
2.0	-20
2.5	-80
3.5	-70

Answer =

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HL only

A postsynaptic neuron receives synapses from several excitatory and inhibitory presynaptic neurons. Explain how these inputs determine whether it generates an action potential.

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HL only

Explain how an action potential is propagated along a myelinated axon.

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Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1]

B B [1]

2. [1]

C C [1]

3. [1] **HL only**

D D [1]

4. [6]

- (a) speeds similar / C 25 m s^{-1} and D 24 m s^{-1} [1]
- (a) D achieves this with a much smaller diameter / C is non-myelinated and D is myelinated [1]
- (b) $500 \div 4 = 125$ times [1]
- (c) (strong) positive correlation [1]
- (c) $R^2 = 0.95^2 = 0.90$ [1] Accept 0.9025.
- (d) fast conduction with narrow fibres, so many fibres fit in a small space / nerve OWTTE [1]
- Accept: rapid responses without needing giant axons.

5. [4]

- depolarization of presynaptic membrane opens (voltage-gated) calcium channels [1]
- Ca^{2+} diffuses into presynaptic neuron [1]
- Ca^{2+} acts as a signal causing vesicles to fuse with presynaptic membrane / exocytosis [1]
- acetylcholine diffuses across the synaptic cleft [1]
- acetylcholine binds to (transmembrane) receptors on postsynaptic membrane [1]
- ion channels open and positive ions / Na^+ diffuse into the postsynaptic cell [1]
- postsynaptic membrane depolarized [1]
- max 4

6. [6] **HL only**

- (a) -70 mV [1]
- (b) threshold potential reached (at -55 mV) [1]
- (b) voltage-gated sodium channels open [1]
- (b) Na^+ diffuses in, depolarizing the membrane / inside becomes positive [1]
- (b) max 2
- (c) sodium channels close [1]
- (c) voltage-gated potassium channels open [1]
- (c) K^+ diffuses out, repolarizing the membrane / overshoot below resting potential (hyperpolarization) [1]
- (c) max 2
- (d) $24 \div 0.40 = 60$ impulses per second [1]

7. [3] HL only

- excitatory neurotransmitters cause depolarization / EPSPs [1]
- inhibitory neurotransmitters cause hyperpolarization / IPSPs [1]
- effects are summed / added together [1]
- action potential only if the summed depolarization reaches the threshold potential [1]
- all-or-nothing response [1]
- max 3

8. [7] HL only

- resting potential about -70 mV / maintained by sodium-potassium pumps [1]
- threshold potential must be reached for an action potential [1]
- voltage-gated sodium channels open and Na^+ diffuses in [1]
- depolarization / inside becomes positive [1]
- voltage-gated potassium channels open and K^+ diffuses out [1]
- repolarization [1]
- local currents: Na^+ diffuses along inside (and outside) of the axon to the next region [1]
- this brings the next region / node to threshold [1]
- myelin sheath insulates the axon [1]
- ion pumps and channels clustered at nodes of Ranvier [1]
- action potential propagated / jumps from node to node: saltatory conduction [1]
- faster than in non-myelinated fibres [1]
- max 7