24.1 Neural signalling: impulses and synapses

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS action potential • synapse

Objective

Neural signalling: impulses and synapses. Original classroom practice for IB HL; not an official IB paper.

1 Key knowledge and worked examples

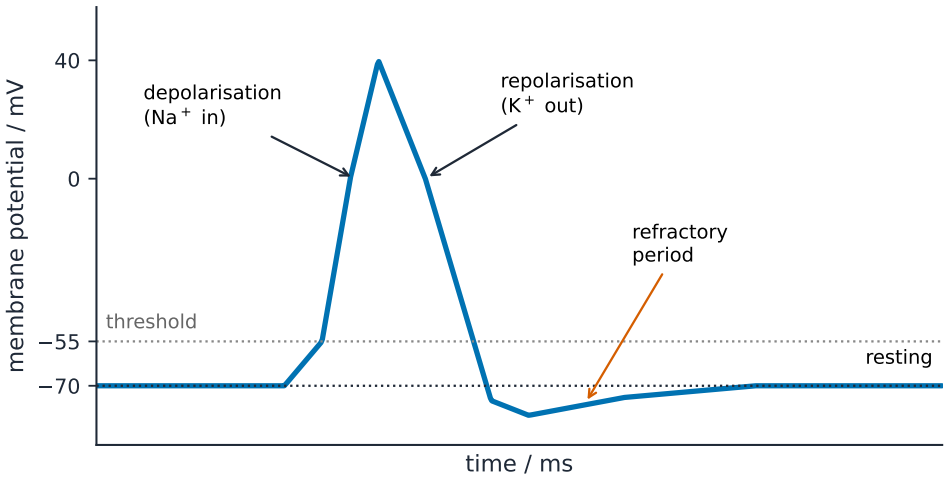
What would explain this observation?

- A stronger stimulus can increase impulse frequency while each **action potential** remains a similar size.

Build the model

- An action potential is a brief change in membrane potential involving voltage-gated ion channels.
- Depolarization followed by repolarization propagates along a neuron.
- At a chemical **synapse** , transmitter release can alter the next cell membrane potential.
- action potential: A brief propagating change in membrane potential.
- synapse: A junction for communication between cells.

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all-or-nothing: once threshold is reached, a full spike fires (no partial APs)

Choose evidence that can test it

- The all-or-none principle applies to an individual action potential.
- Stimulus information can be encoded by frequency and recruitment.
- Myelination permits saltatory conduction between nodes rather than making ions move freely through myelin.

In the lab: Interpret supplied voltage-time traces and compare time intervals. Identify threshold, rising phase and recovery before explaining ions. Use classroom models rather than electrical stimulation of people.

Work from known quantities

- Known: 30 impulses occur in 0.50 s.
- Frequency = count/time = 30/0.50 = 60 Hz.
- This is impulse frequency, not an estimate of propagation speed.

Your turn: 24 impulses occur in 0.40 s. Find impulse frequency.

Check the conclusion and its limits

- A neurotransmitter diffuses across the synaptic cleft; an action potential does not jump intact through the liquid gap.
- Excitatory input does not guarantee the postsynaptic cell reaches threshold.

Not true: A stronger stimulus always makes each action potential larger. Action potentials are all-or-none: once threshold is reached, the impulse has a fixed size set by the ion gradients. A stronger stimulus raises the frequency of impulses, not their amplitude.

Key:

- An action potential is a brief change in membrane potential involving voltage-gated ion channels.
- The all-or-none principle applies to an individual action potential.
- Watch for: A neurotransmitter diffuses across the synaptic cleft; an action potential does not jump intact through the liquid gap.

■ **Write from an impulse frequency of 70 per second**

- 21 impulses occur in 0.30 s.
- Find the frequency. This is not the propagation speed.

2 Practice

2.1 How can stimulus intensity affect an all-or-none signalling system? Choose one answer.

- **A** Through impulse frequency or recruitment
- **B** By giving every impulse unlimited amplitude
- **C** By removing all ion gradients [1]

2.2 24 impulses occur in 0.40 s. Find impulse frequency. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: A stronger stimulus always makes each action potential larger. [2]

2.4 A brief propagating change in membrane potential: write the technical term. [1]

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3 Exam-style questions

3.1 Two records have 30 impulses in 0.5 s and 30 impulses in 1.0 s. Compare frequency. Would either observation determine nerve conduction speed? [4]

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Solutions

2.1 A Each action potential is all-or-none with fixed amplitude, so intensity is coded by how often impulses fire and how many neurons are recruited. Amplitude cannot grow, and removing ion gradients would abolish signalling.

2.2 frequency=count/time=24/0.40=60 Hz.

2.3 False. Action potentials are all-or-none: once threshold is reached, the impulse has a fixed size set by the ion gradients. A stronger stimulus raises the frequency of impulses, not their amplitude.

2.4 action potential. action potential means A brief propagating change in membrane potential.

3.1 60 and 30 Hz. Frequency is count per time; speed requires propagation distance and delay between locations. These are different measured quantities.

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