Model Answers: Easy

1a

(a) The structures labelled A, B and C on Fig. 1 are…

- A = node of Ranvier; [1 mark]
- B = axon; [1 mark]
- C = cell body; [1 mark]

[Total: 3 marks]

The axon is the part of the neurone that carries impulses away from the cell body. We have been told that this cell is a motor neurone so we would expect the cell body to be within the CNS and the impulse would travel away from the CNS towards the effector.

1b

(b) The function of a motor neurone is to…

- Transmit nerve impulses/action potentials from the CNS / relay/intermediate neurones…; [1 mark]
- …to effectors / muscles / glands; [1 mark]

[Total: 2 marks]

1c

(c) The fast transmission of impulses along a motor neurone occurs due to…

Any **four** of the following:

- Schwann cells are wrapped around the axon/B; [1 mark]
- (This forms the) myelin sheath / the axon is myelinated; [1 mark]
- (The myelin sheath) insulates the axon / prevents movement of ions; [1 mark]
- Depolarisation/action potentials can only occur at nodes (of Ranvier)/A; [1 mark]
- Local circuits occur (between one node and the next); [1 mark]
- Action potentials (appear to) jump from node to node / saltatory conduction occurs; [1 mark]

[Total: 4 marks]

Make sure that you can explain exactly how myelination speeds up the conduction of nerve impulses.

2a

(a) (i) The type of membrane potential in the axon at 0.5 ms is…

- Resting (potential); [1 mark]

Resting potential is negative, usually around -70mV in humans, meaning that the inside of the axon is more negative than the outside.

(a) (ii) Resting potential is achieved by…

Any **two** of the following:

- Sodium-potassium pumps pump / use ATP to move (sodium and potassium) ions across the membrane; [1 mark]
- 3 sodium ions are pumped out of the axon for every 2 potassium ions that are pumped in; [1 mark]
- The membrane is permeable to potassium ions **SO** potassium ions diffuse out of the cell/axon; [1 mark]
- The membrane is less permeable to sodium **SO** sodium ions do not diffuse back in; [1 mark]

- Negatively charged proteins / anions are present inside the axon; [1 mark]

Resting potential is achieved primarily by the movement of ions. Sodium-potassium pumps use ATP to move more positively charged ions out of the axon than in; this causes the inside of the cell to become more negative than the outside. The movement of ions creates a concentration gradient for both sodium and potassium ions, but because the membrane is more permeable to potassium ions these diffuse back out of the cell while most sodium ions remain on the outside; this further increases the negative charge inside the cell.

[Total: 3 marks]

2b

(b) When the membrane is stimulated at 1 ms…

- Sodium ion channels open; [1 mark]

[Total: 1 mark]

Note that this question is specifically asking about the events occurring **at 1 ms** when the membrane is stimulated, not what happens after this. Events such as an influx of sodium ions and membrane depolarisation occur after this initial stimulus.

2c

(c) The shape of the curve between 1 - 1.8 ms is due to…

Any **three** of the following:

- Sodium ions move in / there is an influx of sodium ions to the axon/neurone; [1 mark]
- (Sodium ions move) by diffusion / down their concentration gradient; [1 mark]
- If enough sodium ions move into the axon then a threshold (potential) is reached; [1 mark]
- (Reaching a threshold) causes more sodium channels / voltage gated sodium channels to open; [1 mark]
- The membrane is depolarised / the charge across the membrane is reversed / the inside of the axon becomes positive; [1 mark]

[Total: 3 marks]

The curve between 1 - 1.8 ms shows that the membrane potential is increasing. This occurs due to the **inward movement of positive sodium ions down their concentration gradient**. If enough sodium ions enter the axon then a **threshold** is reached and **more sodium ion channels open**, allowing a **further influx** of sodium ions. The inward movement of positive ions causes the inside of the axon to become more positive than the outside and the membrane is said to have **depolarised**.

Be aware that the question is only asking for information about the events occurring **between 1 - 1.8 ms** so there are no marks available for explaining repolarisation or the restoration of resting potential.

2d

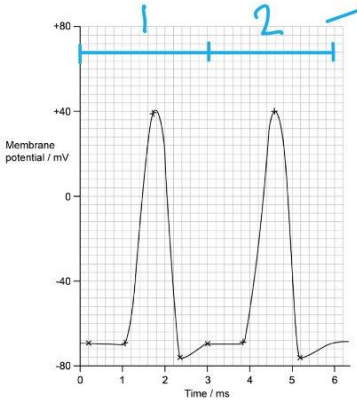
(d) The number of action potentials that will occur in 1 second is…

- 1000 ÷ 3 **OR** ; [1 mark]
- 333 (action potentials); [1 mark]

Full marks can be awarded for the correct answer in the absence of calculations.

[Total: 2 marks]

Calculate the frequency of action potentials:



Two complete action potentials are shown in the graph

2 action potentials in 6 ms = 1 action potential in 3 ms

Calculate the number of action potentials that will occur in 1 s:

1000 ms per s

= 1000 ÷ 3 [1 mark]

How many times will 3 ms fit into 1 s

= 333.3

= 333 [1 mark]

Rounded to give the number of complete action potentials.

3a

(a) Structures A-C are...

- A = synaptic cleft; [1 mark]
- B = (pre)synaptic knob / presynaptic cell/neurone/membrane; [1 mark]
- C = postsysnaptic cell/neurone/membrane; [1 mark]

[Total: 3 marks]

3b

(b) Neurotransmitters interact with the structures labelled **D** to bring about an action potential in the new neurone by...

Any **two** of the following:

- Binding to (specific) receptors / receptor proteins (D); [1 mark]
- (This causes) sodium ion channels to open; [1 mark]
- Sodium diffuses into the (postsynaptic) cell; [1 mark]
- If enough (sodium enters the cell) then a threshold will be reached (and an action potential generated); [1 mark]

[Total: 2 marks]

3c

(c) (i) The specialised junctions between motor neurones and muscles are...

- Neuromuscular junctions; [1 mark]

(c) (ii) Differences between neuromuscular junctions and synapses include...

Any **one** of the following:

- The cell that receives the neurotransmitter/second cell/postsynaptic cell (at neuromuscular junctions) is always a muscle cell **WHILE** (at regular synapses) the cell that receives the neurotransmitter/second cell/postsynaptic cell can be many cell types / a named example of another cell type, e.g. an intermediate nerone; [1 mark]
- T-tubules are present / the depolarisation travels/spreads along T-tubules (at neuromuscular junctions) **WHILE** they are not present / the depolarisation remains at the cell surface membrane (in regular synapses); [1 mark]
- Calcium diffuses from the sarcoplasmic reticulum (at neuromuscular junctions) **WHILE** this does not occur / there is no calcium/sarcoplasmic reticulum (in the postsynaptic cell of a regular synapse); [1 mark]

While you may not have learned any specific examples of differences between regular synapses and neuromuscular junctions, your knowledge of both should allow you to answer this question. **T-tubules** and the **sarcoplasmic reticulum** are key parts of the events that occur at a neuromuscular junction, so these are good places to start.

When describing the differences between two things you should always ensure that **each statement is clearly comparative**. You will get no credit if you just describe a neuromuscular junction here.

Note that neuromuscular junctions are still **synapses**, but they are a **specialised type of synapse** and so differ slightly from regular cholinergic synapses.

[Total: 2 marks]

3d

(d) (i) The length of a contracted sarcomere is...

- 3.1 x 0.095 **OR** 0.29/0.295; [1 mark]
- (3.1 - 0.29 =) 2.81/2.805 (µm); [1 mark]

Award full marks for the correct answer in the absence of other calculations.

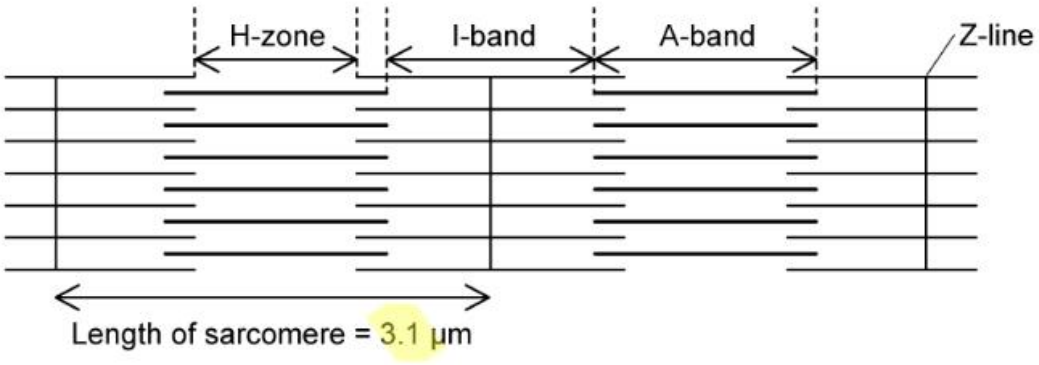


Fig. 2

When the sarcomere contracts it reduces in length by 9.5 %.

Calculate the length of a contracted sarcomere.

Calculate 9.5 % of 3.1 µm:

3.1 x 0.095 = 0.29 [1 mark]

95 % as a proportion = 0.095

Calculate how much shorter the sarcomere will be after contracting by 9.5 %:

3.1 - 0.29 = 2.81 µm [1 mark]

(d) (ii) Changes that will occur in Fig. 2 as a result of stimulation of the striated muscle include...

Any **two** of the following:

- The H zone will get shorter; [1 mark]
- The I band will get shorter; [1 mark]
- The Z lines will move closer together; [1 mark]

Remember that the A band does not change in length during muscle contraction. This is because the A band represents the length of the myosin filaments and these do not change in length during contraction, they just overlap further with actin.

[Total: 4 marks]