Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 3 QUESTION PACK

1074 (Legacy BY4) + 1075 (Legacy BY5) · New spec Unit 3 Topic 10 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE
.wales

BIOLOGY — UNIT 3 · NERVOUS SYSTEM — NEURONES & ACTION POTENTIALS

3.6 The nervous system — neurone structure and the generation of an action potential

Structure of motor and sensory neurones (cell body, dendrites, axon, Schwann cells, myelin sheath, nodes of Ranvier), the resting potential maintained by Na^+/K^+ pumps, depolarisation, repolarisation, hyperpolarisation, the refractory period, and saltatory conduction in myelinated axons.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~2 h 29 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (93 marks over 8 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY4 (and BY5, where relevant) papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 3 Topic 10 (3.6).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

For Examiner's use only

Q	Source	Max	Mark
1	BY4 Jun 11 Q3	12	
2	BY4 Jun 12 Q5	13	
3	BY4 Jun 13 Q6	12	
4	BY4 Jun 15 Q1	4	

Q	Source	Max	Mark
5	BY4 Jun 16 Q7	12	
6	BY4 Jan 12 Q1	14	
7	BY4 Jan 13 Q5	17	
8	BY4 Jan 14 Q3	9	
Total		**93**	

Nervous System — Neurones & Action Potentials — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.6.

Neurone types

- Sensory: receptor → CNS (one long dendron, cell body on side).
- Motor: CNS → effector (cell body in CNS, long axon).
- Relay: within CNS, multiple short processes.

Resting potential

- Inside ~−70 mV relative to outside.
- Na^+/K^+ pump: 3 Na^+ out, 2 K^+ in (uses ATP).
- Membrane more permeable to K^+ than Na^+ at rest.

Action potential

- Stimulus opens Na^+ voltage-gated channels → depolarisation to +40 mV.
- K^+ channels open → repolarisation; brief hyperpolarisation.
- All-or-nothing: stimulus must reach threshold (typ. −55 mV).

Refractory period

- Absolute: Na^+ channels inactivated, no second AP possible.
- Relative: Na^+ recovering, larger stimulus needed.
- Sets the maximum firing frequency.

Saltatory conduction

- Myelin from Schwann cells insulates the axon.
- AP jumps node-to-node (nodes of Ranvier).
- Much faster than continuous conduction in unmyelinated axons.

Speed factors

- ↑ axon diameter ⇒ faster (less internal resistance).
- Myelin ⇒ saltatory conduction ⇒ faster.
- Temperature ↑ (within limits) ⇒ faster.

Crib sheet »

Nervous System — Neurones & Action Potentials in one page

Quick-reference notes — revisit before each question.

Neurone types

Motor: cell body in CNS, long axon to effector.

Sensory: receptor → CNS, single long dendron + axon.

Relay: short, inside CNS.

Myelin sheath

Schwann cells wrap axon.

Nodes of Ranvier between cells — gaps in myelin.

Insulates → AP jumps node-to-node (saltatory).

Resting potential

~−70 mV inside.

Na/K pump: 3 Na^+ out, 2 K^+ in.

Membrane more permeable to K^+ ⇒ net negative inside.

Action potential

Threshold (−55 mV) → Na^+ channels open.

Rapid depolarisation to +40 mV.

K^+ channels open → repolarisation.

Brief hyperpolarisation → refractory.

All-or-nothing

Below threshold: no AP.

At or above: full AP, fixed amplitude.

Stimulus strength coded by frequency, not size.

Refractory period

Absolute: Na channels inactive; no AP possible.

Relative: needs larger stimulus.

Sets the upper firing frequency.

Saltatory conduction

AP regenerates only at nodes.

Fast: ~120 m s^{-1} in mammalian motor axons.

Cheaper energetically (fewer ions to restore).

Speed factors

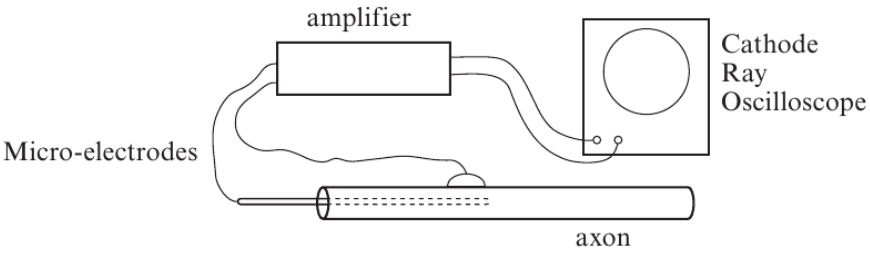
↑ axon diameter ⇒ faster.

Myelin ⇒ saltatory ⇒ faster.

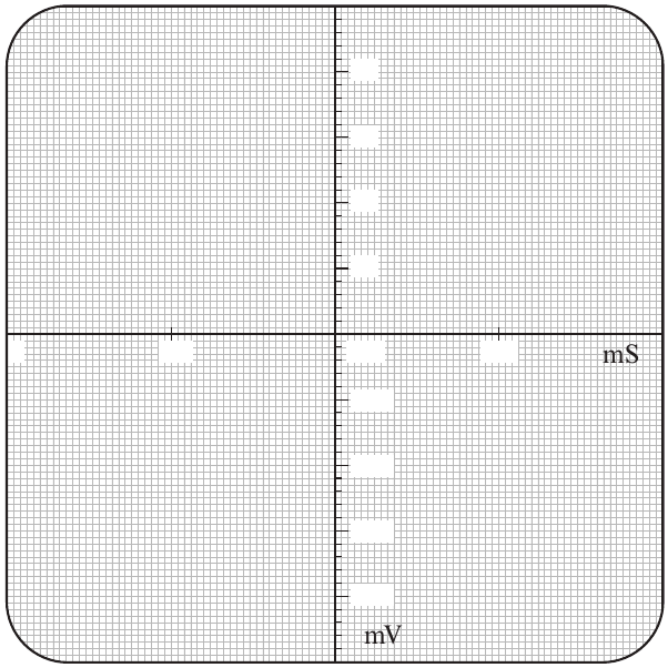
Warmer (within tolerance) ⇒ faster.

Examiner only

3. *(a)* The equipment shown in the diagram below is used to measure electrical potential across the membrane of squid giant axons.



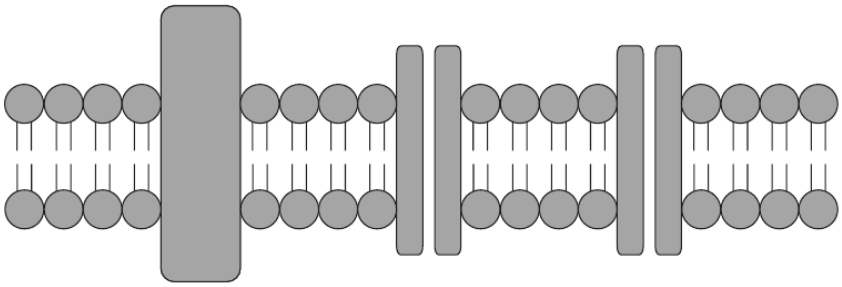
(i) Use the grid below to draw a typical action as it would appear on the screen of the cathode ray oscilloscope. [2]



(ii) Label your Action Potential to show, depolarisation and repolarisation. [1]

Examiner only

(b) The diagram below shows the structural components of the axon membrane that are responsible for the potentials measured in part *(a)*.



(i) From which type of biological molecules are the following made?

pumps and channels ..... [1]

the bilayer ..... [1]

(ii) With reference to the diagram, describe how the following events are brought about. [4]

Resting Potential .....

.....

.....

Depolarisation .....

.....

.....

(c) Explain how impulses are transmitted across a synapse. [3]

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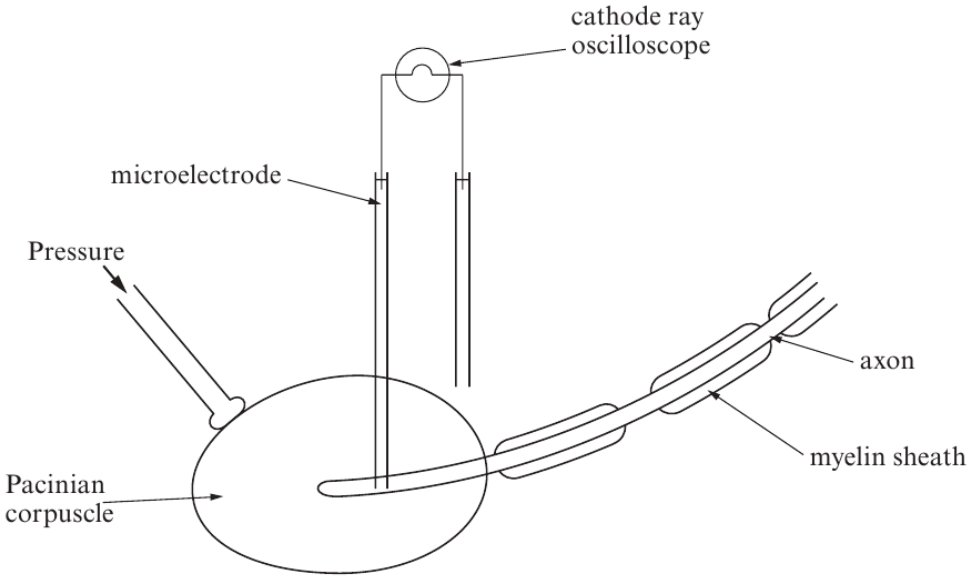
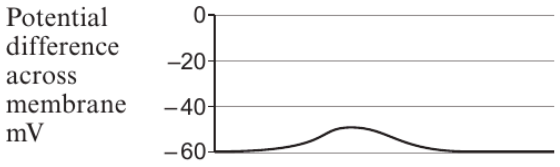
(Total 12 marks)

Examiner only

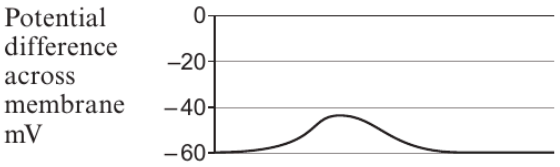
5. Pacinian corpuscles are receptors found in the skin and consist of a **single sensory neurone** surrounded by connective tissue. They respond to changes in pressure.
The Pacinian corpuscle was stimulated and the electrical activity across the membrane of the sensory neurone was recorded using a microelectrode as shown.



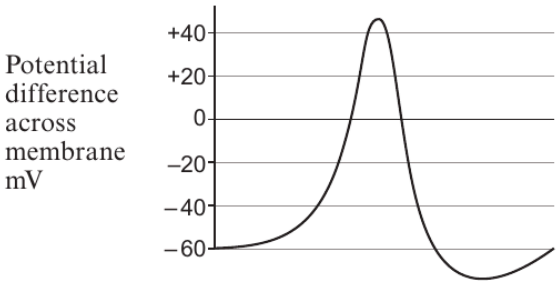
Oscilloscope readings



Light pressure



Medium pressure



Heavy pressure

Examiner only

(a) (i) Explain the change in potential difference shown by the microelectrode after light pressure was applied. [3]

(ii) Explain the change in potential difference across the membrane shown by the microelectrode when heavy pressure was applied. [6]

Examiner only

(b) Many chemical substances affect the transmission of the nerve impulse across the synapse.
Suggest **two** ways by which excitatory drugs could change activity at the synapse and **two** ways by which chemicals could inhibit activity at the synapse. [4]

Possible mode of activity of excitatory drugs:

1 .....

.....

2 .....

.....

Possible mode of activity of inhibitory chemicals.

1 .....

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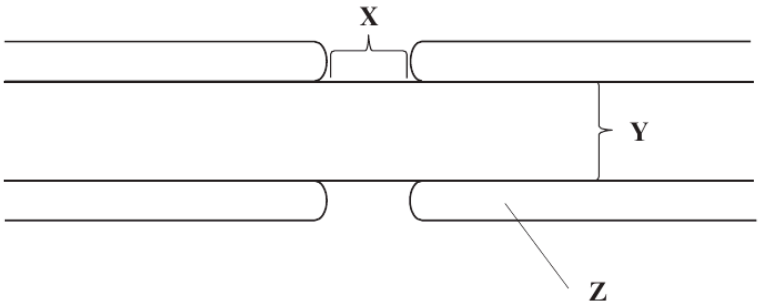
2 .....

.....

(Total 13 marks)

Examiner only

6. The diagram below represents part of a myelinated neurone.



(a) Name **X** and **Y** shown on the diagram above. [2]

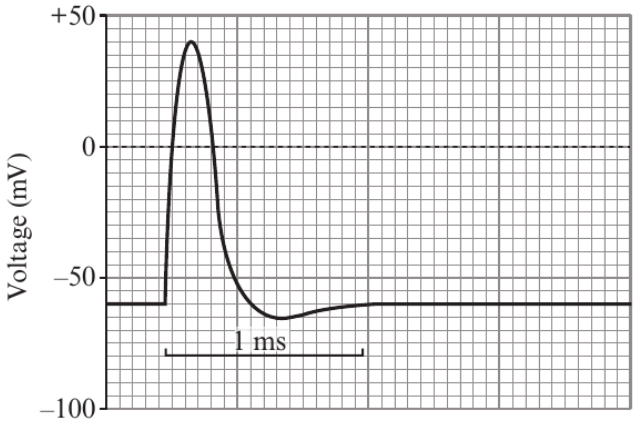
X ..... **Y** .....

(b) Name the cell type that forms layer **Z**. [1]

.....

Trace **A** below is an oscilloscope recording of changes in voltage across the membrane of a myelinated neurone during an action potential.

Trace **A**



(c) Use Trace **A** to estimate the resting potential of **this neurone**. [1]

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Examiner only

(d) (i) Explain, in terms of movement of ions, what causes the rise in membrane potential seen in Trace **A** opposite. [2]

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(ii) State the name given to the rapid fall in membrane potential seen in Trace **A**. [1]

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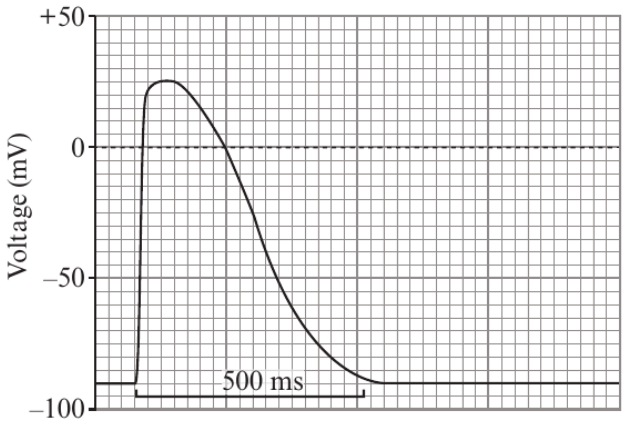
Trace **B** is another oscilloscope recording, showing changes in voltage across the membrane of a cardiac muscle fibre.

Trace **B**



(e) Compare Trace **A** and Trace **B** by giving two differences between them. [2]

1. .....

.....

2. .....

.....

(f) Suggest how cardiac muscle fibres would respond when the voltage across the membrane rises. [1]

.....

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Examiner only

Answer **all** *questions.*

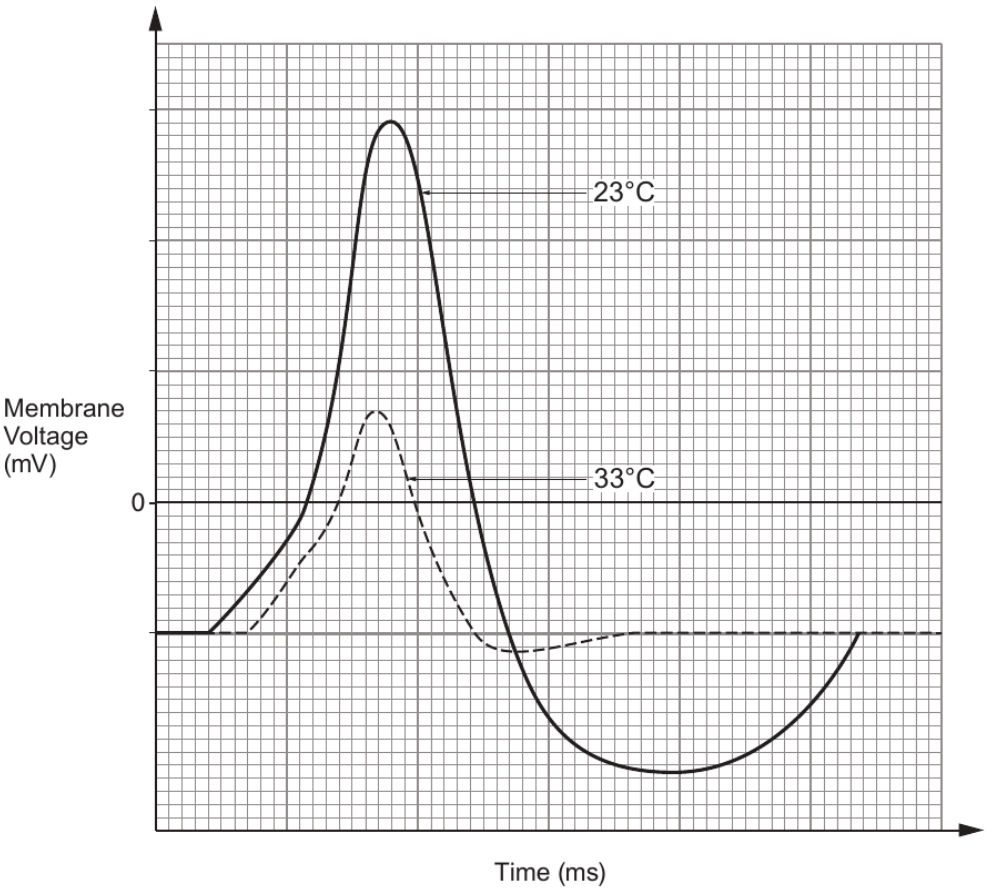
1. Complete the following table indicating whether the statement is true or false by placing a tick (✓) in the correct box. [4]

Statement	True	False
Motor neurones have only a single dendrite.		
Motor neurones have many axons.		
Dendrites receive and integrate impulses.		
Dendrites of motor neurones are rarely myelinated.		

4

Examiner only

7. Experiments were carried out to determine the effect of temperature on action potentials in mammalian ear cells. Results are shown below.



(a) Use the graph to describe **three** effects of an increase in temperature on the action potential. [3]

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Examiner only

(b) The scientists concluded that the opening and closing of potassium gated channels was temperature dependent. Suggest an explanation for the differences shown in the traces. [2]

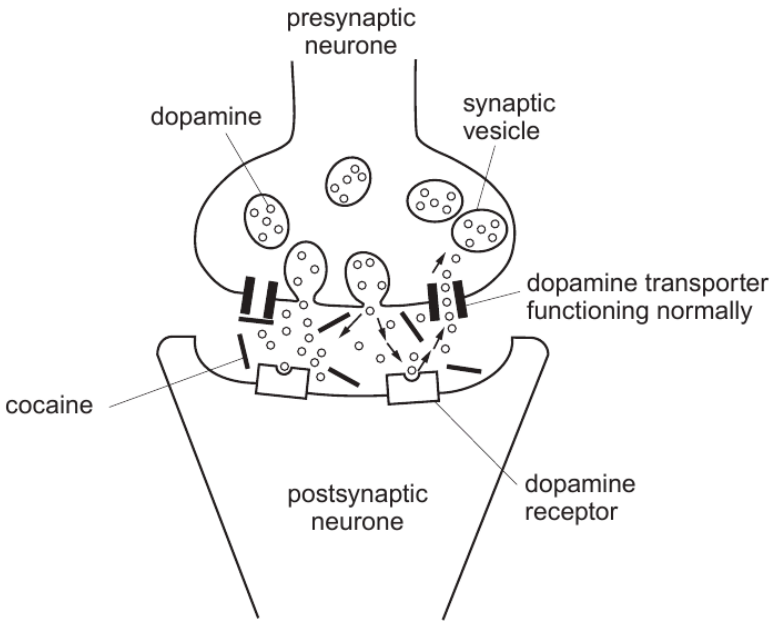
(c) Research has shown that the brains of people with Alzheimer's disease show a loss of function of nerve cells that use the neurotransmitter acetylcholine. The loss of function of these nerve cells is related to the severity of symptoms that people experience. There are no drug treatments available that can provide a cure for Alzheimer's disease. However, medicines have been developed that can reduce symptoms, or temporarily slow down their progression, in some people.

(i) Briefly describe how the normal functioning of the synapse causes depolarisation of the post synaptic membrane. [2]

(ii) It has been noted that patients who are given acetylcholinesterase inhibitors have improved synapse function. Describe the action of acetylcholinesterase inhibitors and why they would result in improved synapse function. [2]

Examiner only

(d) The diagram below shows the effect of cocaine on synapses where the neurotransmitter is dopamine.



Describe and explain the effect that cocaine has on the synapse. [3]

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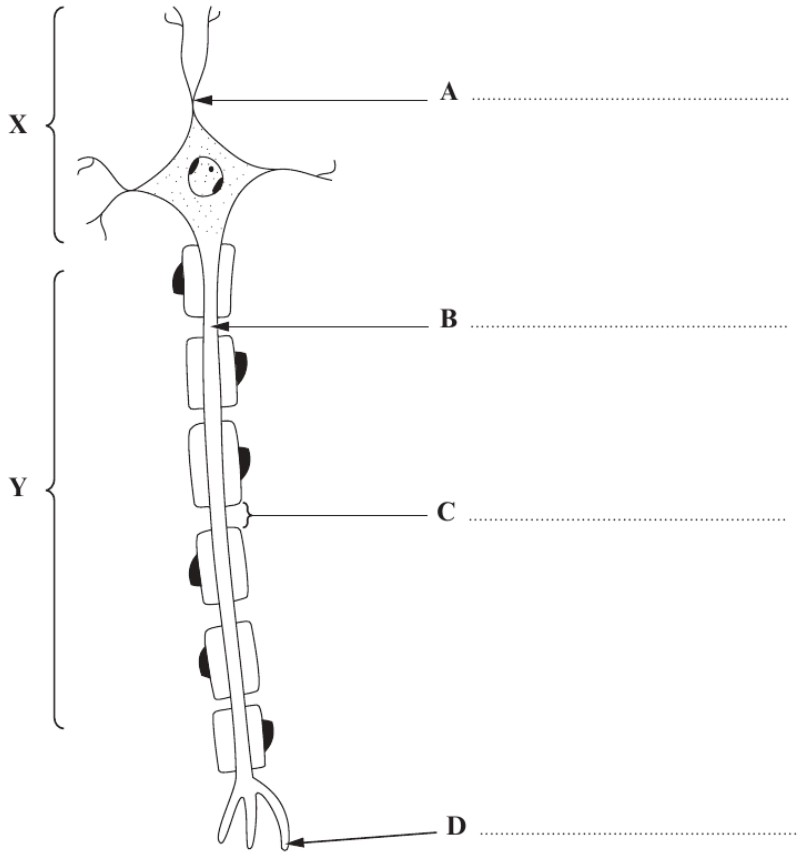
Examiner only

1. *(a)* (i) Label structures **A-D** on the diagram of the motor neurone below. [4]



(ii) Give the names of **two different types** of effectors. [2]

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(iii) Where in the spinal cord would you find structure **X**? [1]

.....

.....

(iv) In which spinal cord root would you find structure **Y**? [1]

.....

Examiner only

(b) (i) Complete the following which describes how the myelin sheath is formed. [3]

During embryonic development ..... cells become associated with axons and dendrons. These cells ..... around the axon forming a layer called the myelin sheath. This layer is formed of many layers of ..... .

(ii) What are the functions of the myelin sheath? [3]

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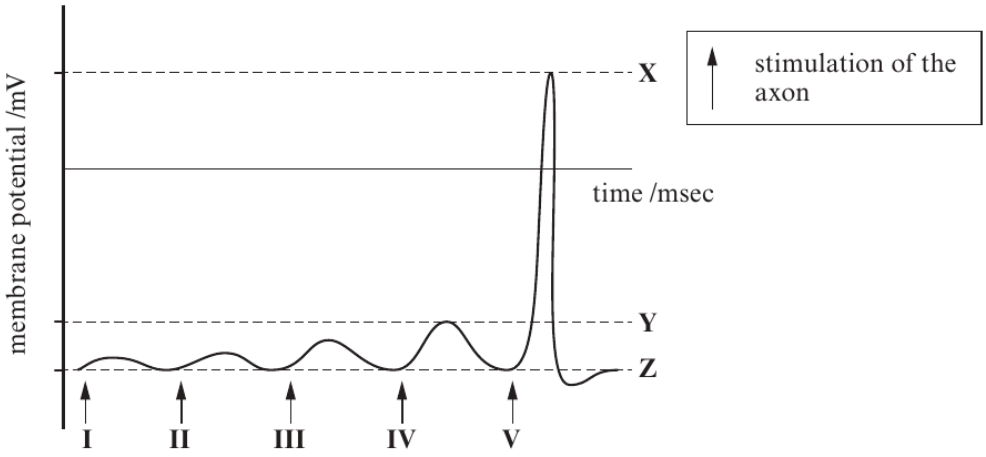
(Total 14 marks)

Examiner only

5. *(a)* The axon of a motor neurone was stimulated using an intracellular electrode. The strength of each stimulus was increased by the same amount each time and the potential difference across the cell membrane was monitored using an oscilloscope.

The results of the experiment are shown in the graph below.



(i) Suggest values for the membrane potential at: [1]

X ..... mV and Z ..... mV

(ii) Generation of an action potential involves ion-channels.

Explain how opening and closing of ion channels results in the depolarisation and repolarisation of the axon membrane shown at point **V** on the graph.

I. Depolarisation; [2]

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II. Repolarisation. [2]

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Examiner only

(iii) Explain why an action potential was not generated by stimuli **I** to **IV**. [2]

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(b) At rest the sodium-potassium pump helps to maintain a constant membrane potential. A model of this protein is shown in the diagram below.

(i) The sodium-potassium pump has a quaternary structure.

Explain what is meant by the term **quaternary structure**. [2]

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(ii) On the diagram above use a letter **H** to label a region of the sodium-potassium pump that would have hydrophobic properties. [1]

(iii) Explain why this region would be hydrophobic. [1]

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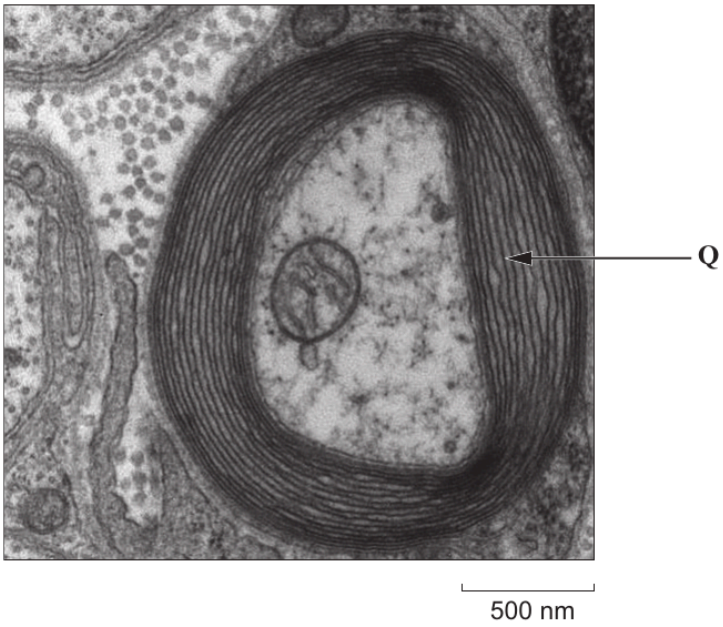
Examiner only

(c) The transmission electron micrograph below shows a cross section of the axon of a motor neurone.



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(i) Name the substance you would expect to find at **Q** shown on the diagram above. [1]

.....

(ii) Name the cell that produces this substance. [1]

.....

(iii) Explain how the substance secreted by these cells and their arrangement along the neurone affect the speed of transmission of a nerve impulse. [4]

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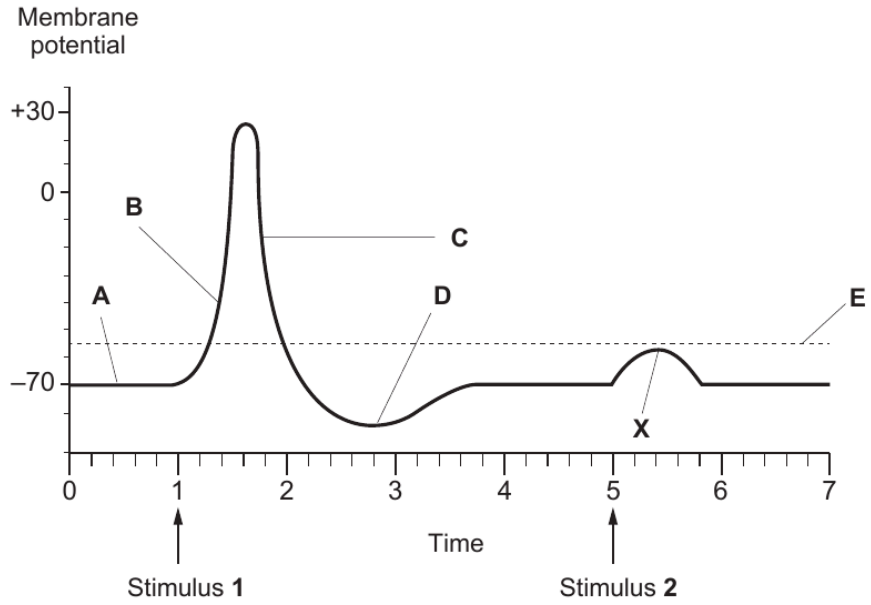
Examiner only

3. An action potential is illustrated in the following graph.



(a) What units should be used on the two axes of the graph shown above? [2]

Membrane potential .....

Time .....

(b) Identify the stages of the action potential indicated by **A**, **B**, **C** and **D**. [4]

A .....

B .....

C .....

D .....

(c) (i) What is represented by line **E** on the graph above? [1]

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(ii) Explain why stimulus **2** failed to initiate an action potential as seen at point **X**. [2]

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END OF QUESTION PACK

8 questions · 93 marks · ~2 h 29 min
Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 3 — Topic 10 (3.6)