

The Nervous System

Mark Scheme



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1. The human nervous system allows organisms to react to their surroundings and coordinate their behaviour. Circle the letter of the correct answer for each question below.

- a) The figure below shows a motor neurone.

At the junction between a relay neurone and a motor neurone, neurotransmitters are released. To which part of the motor neurone do these neurotransmitters typically bind?

E – is the only correct answer.	1 mark
	Total: 1 mark

- b) What is the correct sequence in a reflex arc?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) The figure below shows a synapse. At this junction, a neurotransmitter chemical diffuses across the gap and binds to receptor sites on the next neurone, allowing an impulse to be generated.

Using the information provided and your own knowledge, describe the role of the neurotransmitter in synaptic transmission.

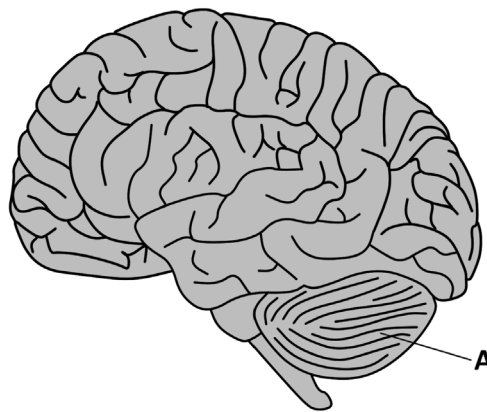
B – is the only correct answer.	1 mark
	Total: 1 mark

- d) The figure below shows a sensory neurone. Which letter which label shows the myelin sheath?

B – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. The figure below shows the structure of a human brain.



a) Identify structure A and give its function.

Structure A: <u>Cerebellum</u> .	(1)
Function: Controls/coordinates balance/ movement / muscle activity.	(1)
	Total: 2 marks

b) In response to a stimulus, nerve impulses are transmitted from the brain to the muscles.

Describe how impulses are sent from the brain to the muscles.

(Nerve impulse travels along a) motor neurone	(1)
Allow: nerve / nerve cell.	
(At the end of the neurone) a chemical / neurotransmitter is released (into the synapse)	(1)
Allow: chemical message.	
which causes the muscle (cells) to contract.	(1)
Allow: stimulates the effector.	
	Total: 3 marks

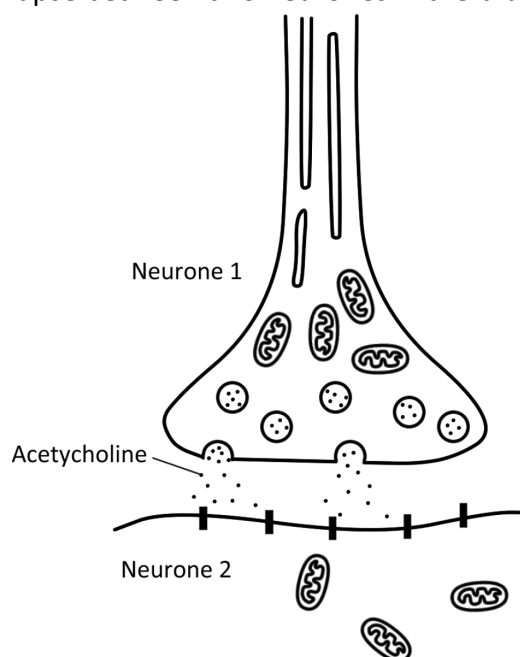
c) Most neurones in the brain are unmyelinated whereas motor neurones are myelinated.

Explain why myelination is needed on motor neurones but not on neurones in the brain.

Myelin sheath acts as an (electrical) insulator which speeds up the transmission of the nerve impulse.	(1)
Allow: makes the impulse 'jump' between gaps / nodes.	
This is needed for motor neurones because they transmit impulses over long distances (from the CNS to effectors).	(1)
Allow: for rapid responses / faster reactions.	
Neurones in the brain are much shorter / only transmit impulses over very short distances, so high-speed transmission is not as necessary.	(1)
	Total: 3 marks

Alzheimer's is a degenerative brain disease that causes brain cells to degenerate and . Common symptoms include difficulties moving, having a decline in memory, and reduced ability to think.

The figure below shows a synapse between two neurones in the brain.



Acetylcholine is a neurotransmitter in the brain. Scientists observe that in a brain affected by Alzheimer's disease, the neurotransmitter acetylcholine requires 6.8×10^{-7} s to diffuse across the 30 nanometre synaptic gap between neurones. 1 metre = 10^9 nanometres

- d) Calculate the speed of the Acetylcholine diffusion across the synapse in a person with Alzheimer's disease. Use this formula: **speed = distance $\div$ time**

Give your answer in metres per second.

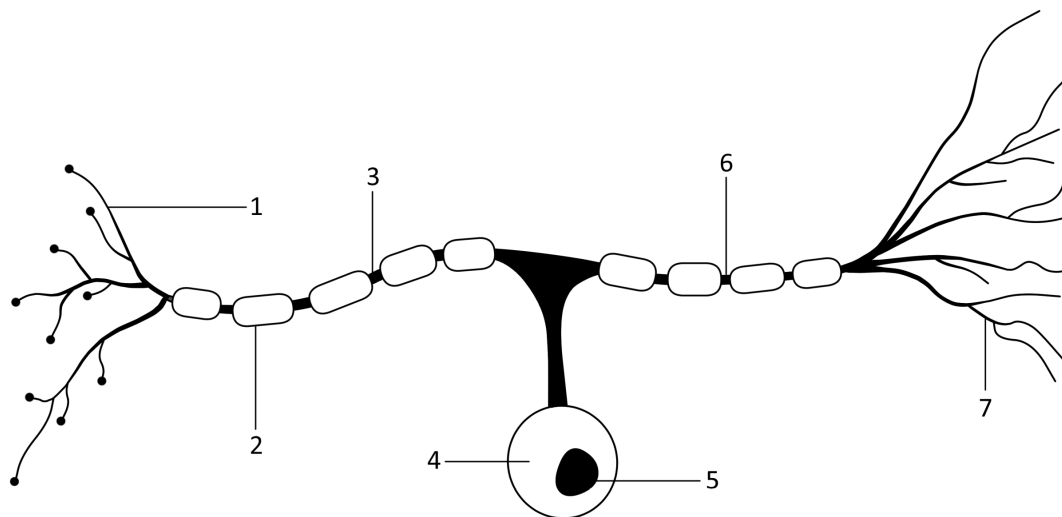
Step 1: Convert distance $30 \div 10^9$ or 30×10^{-9} (m)	(1)
Award 1 mark for correct conversion of distance to metres. Allow: 3×10^{-8} (m).	
Step 2: Substitution Speed = $(30 \times 10^{-9}) \div (6.8 \times 10^{-7})$	(1)
Award 1 mark for correct substitution into the formula.	
Step 3: Final Answer 0.044 (m/s)	(1)
	Total: 3 marks

- e) In a healthy person the speed of diffusion of Acetylcholine is 0.4 metres per second. How does the result in part (d) explain the symptoms of Alzheimer's disease?

The speed of diffusion is slower (in the person with Alzheimer's).	(1)
Slower transmission of impulses leads to slower brain function / processing of information, which explains the symptoms (of memory loss / difficulty thinking / slow movement)	(1)
	Total: 2 marks

(Total for Question 2 is 13 marks)

3. The figure below shows a sensory neurone.



a) Identify the structures labelled 1 to 7 from the figure below.

1 = Axon terminal	
2 = Myelin sheath	
3 = Axon	
4 = Cell body	
5 = Nucleus	
6 = Dendron	
7 = Dendrites	
	Total: 2 marks

b) Describe the role of sensory neurones in the nervous system.

Transmit / carry (electrical) impulses / signals.	(1)
Allow: information / messages.	
From receptors / sense organs to the Central Nervous System (CNS) / brain / spinal cord.	(1)
Do not allow 'to the effector'.	
	Total: 2 marks

c) Describe **two** distinct structural features of a sensory neurone that differ from those of a motor neurone.

Award one mark for each correct structural feature. Any two from:	
The cell body is in the middle (of the axon / fibre) / located off to the side.	(1)
Has a (long) dendron.	(1)
Has short dendrites / dendrites at both ends.	(1)
	Total: 2 marks

(Total for Question 3 is 8 marks)

4. A student accidentally touches a hot beaker in a science lab and immediately pulls their hand away.

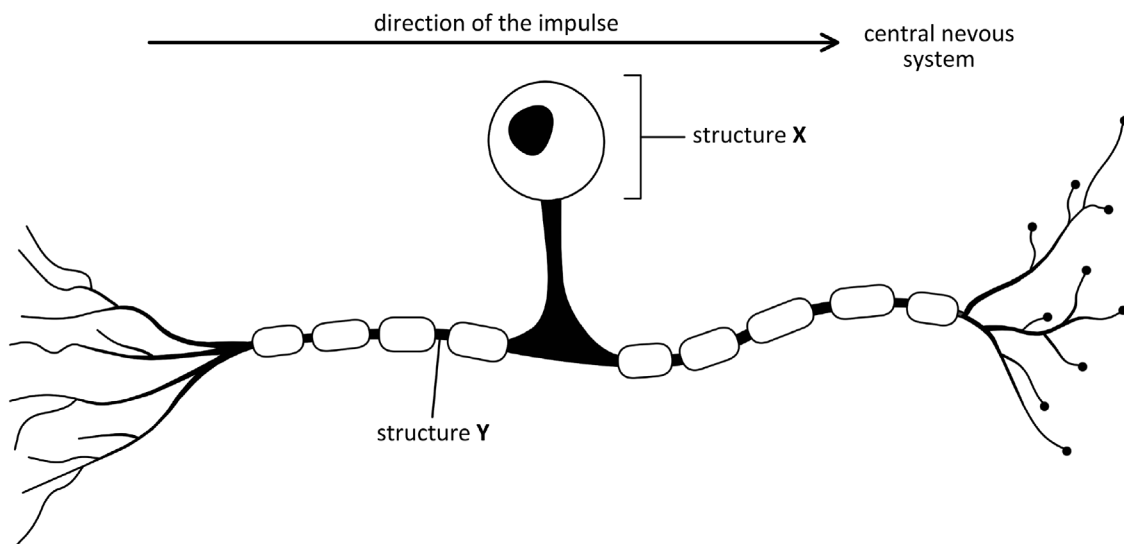
Describe, in detail, the pathway of the nerve impulse in the reflex arc that results in the student pulling their hand away. You should also explain why reflex actions like this are important for survival.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic description is given. May identify some components of the reflex arc, but the sequence may be incorrect or incomplete.
Level 2	3 - 4	A generally correct description of the reflex arc is provided, with most components in the correct sequence. An attempt is made to explain the importance of the reflex for survival. The answer may lack some detail.
Level 3	5 - 6	A detailed and coherent description of the reflex arc pathway is given, with all key components identified in the correct sequence. A clear and logical explanation is provided for why reflex actions are important for survival, linking their speed and automatic nature to protection from harm.

Indicative content:	
Part 1: The Pathway of the Nerve Impulse (The Reflex Arc). Stimulus: Heat from the beaker is detected. Receptor: Pain/heat receptors in the skin of the hand detect the stimulus. Sensory Neurone: An electrical impulse is generated and travels along a sensory neurone towards the spinal cord (CNS). Synapse & Relay Neurone: The impulse arrives at a synapse with a relay neurone. Chemicals (neurotransmitters) are released to carry the signal across the gap. Relay & Motor Neurone: The impulse travels along the relay neurone and crosses a second synapse to a motor neurone. Motor Neurone: The impulse travels along the motor neurone away from the spinal cord. Effector & Response: The impulse reaches an effector, which is a muscle in the arm. The muscle contracts, causing the hand to be rapidly pulled away from the beaker. Part 2: Explanation of Importance for Survival. • The marks for this part are awarded for explaining the features of a reflex and linking them to survival. • Reflex actions are automatic and involuntary (they do not require conscious thought). • They are extremely rapid / fast. • This is because the nerve pathway is very short and bypasses the conscious processing parts of the brain. • This speed minimises harm, injury, or damage to the body from potentially dangerous stimuli (like heat, sharp objects etc.). • Therefore, they act as a protective mechanism, which increases an organism's chances of survival.	
	Total: 6 marks

(Total for Question 4 is 6 marks)

5. The figure below shows a sensory neurone



a) Identify the structures labelled in the figure above.

Structure X: Cell body	(1)
Structure Y: Myelin sheath	(1)
	Total: 2 marks

b) To what do sensory neurones carry impulses to?

The Central Nervous System / CNS	(1)
	Total: 1 mark

c) What is the function of the myelin sheath?

Acts as an (electrical) insulator / insulates the axon.	(1)
(This) speeds up the transmission of the (nerve) impulse.	(1)
	Total: 2 marks

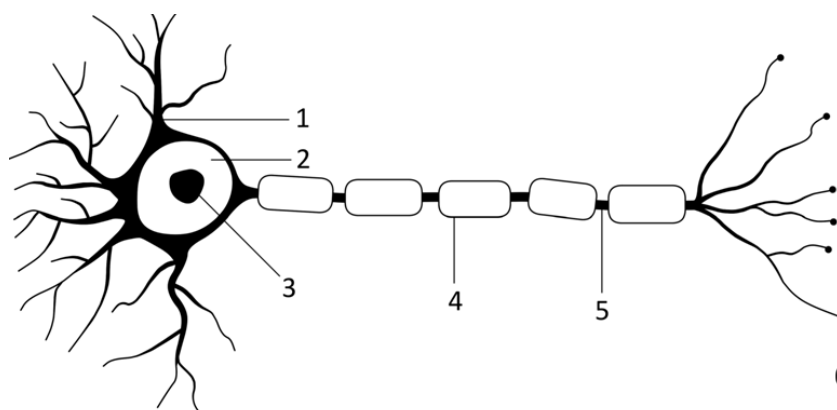
d) Explain how impulses are transmitted at synapses.

(When the electrical impulse reaches the end of a neurone) a chemical is released.	(1)
Allow: neurotransmitter. Ignore: reference to vesicles.	
This chemical <u>diffuses</u> / moves across the gap / synapse.	(1)
Do not allow: travels / is transmitted.	
The chemical binds to receptors on the membrane of the next neurone.	(1)
Allow: is detected by / joins to the next neurone.	
This starts a new (electrical) impulse in the next neurone.	(1)
	Total: 4 marks

(Total for Question 5 is 9 marks)

6. Motor Neurone Disease (MND) is a rare, progressive condition that attacks and destroys the motor neurones. MND badly affects the speed of nerve impulse in motor neurones.

The figure below shows a motor neurone.



- a) Identify the structures labelled 1 to 6 from the figure below.

1 = Dendrites	
2 = Cell body	
3 = Nucleus	
4 = Myelin sheath	
5 = Axon	
6 = Axon terminal	
	Total: 3 marks

- b) Describe the specific role of motor neurones in enabling an organism to respond to a stimulus.

A description to include the following:	
Transmit / carry (electrical) impulses.	(1)
Allow: signals / messages.	
From the central nervous system (CNS).	(1)
Allow: brain / spinal cord / relay neurone. Do not allow from a receptor.	
to an effector (to bring about a response).	(1)
Allow: a muscle or a gland. The response can be muscle contraction or hormone secretion.	
	Total: 3 marks

- c) Motor neurones have an axon. State the function of the axon in a motor neurone.

To carry / transmit the (electrical) impulse. Allow: signals / information.	(1)
away from the cell body / over a long distance.	(1)
	Total: 2 marks

- d) The nervous system also makes use of sensory neurones.

Describe the role of sensory neurons in enabling an organism to respond to a stimulus.

A description to include the following:	
Transmit / carry (electrical) impulses.	(1)
Allow: signals / messages.	
from receptors / sense organs (which detect the stimulus).	(1)
Allow: a specific example e.g., 'from heat receptors in the skin'.	
to the Central Nervous System (CNS) / brain / spinal cord.	(1)
	Total: 3 marks

- e) Some painkillers prevent neurotransmitters binding to receptors in a synapse.

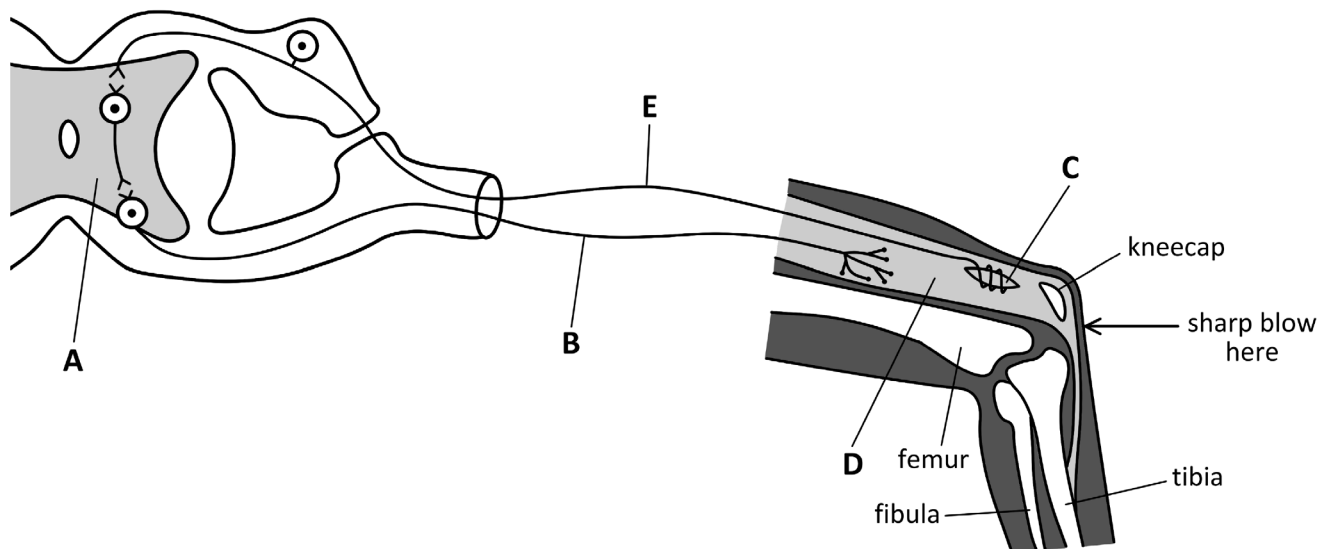
Explain how a signal is transmitted at a synapse and how the painkillers reduce the pain felt by the person.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple statements are made about synaptic transmission and/or the action of painkillers.
Level 2	3 - 4	A good explanation is provided, addressing both synaptic transmission and the action of the painkiller. One part may be described in more detail than the other.
Level 3	5 - 6	A detailed and coherent explanation of both synaptic transmission and the action of the painkiller is given. The answer demonstrates a clear understanding of the process, with logical links between points.

Indicative content:	
<u>Part 1: How a signal is transmitted at a synapse (normal process).</u> Step 1: An electrical impulse arrives at the end of the first neurone. Step 2: This causes the release of chemicals called neurotransmitters. Step 3: The neurotransmitters diffuse across the gap (the synapse). Step 4: They bind to specific receptors on the membrane of the next neurone. Step 5: This binding triggers a new electrical impulse in the second neurone, continuing the signal. <u>Part 2: How the painkillers reduce pain</u> Step 6: The painkiller molecules have a shape that allows them to fit into and block the receptors on the second neurone. Step 7: Because the receptors are blocked, the neurotransmitters cannot bind to them. Step 8: This means that a new electrical impulse is not generated in the second neurone. Step 9: The pain signal is therefore stopped at the synapse and does not reach the brain. Step 10: As a result, the person does not feel the pain, or the sensation of pain is reduced.	
	Total: 6 marks

(Total for Question 6 is 17 marks)

7. The figure below shows a simplified reflex arc for the knee.



a) Identify the structures labelled **A**, **B**, **C** and **D** from the figure above.

A = Spinal cord. Allow: Grey matter or vertebra.	(1)
B = Motor neurone.	(1)
C = Receptor.	(1)
D = Effector. Allow: Muscle / Quadriceps muscle.	(1)
Total: 4 marks	

b) Explain **two** ways in which reflex arcs are beneficial to the survival of an organism.

An explanation to include:	
They are rapid / fast, which minimises harm / damage to the body.	(1)
They are automatic / involuntary, which means they do not involve conscious thought, freeing the brain to carry out other tasks.	(1)
Total: 2 marks	

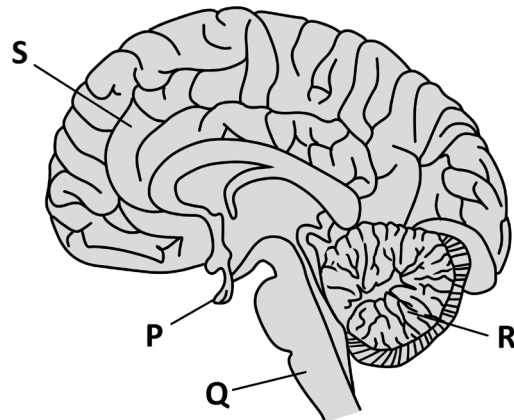
c) Identify the structure labelled **E** and explain its function in the nervous system.

Identity of E: Sensory neurone.	(1)
Function: Carries / transmits (electrical) impulses.	(1)
from a receptor to the CNS / spinal cord.	(1)
Allow: signals / information.	
Total: 3 marks	

d) State the **two** parts of the central nervous system.

Brain	(1)
Spinal cord.	(1)
Total: 2 marks	

The figure below shows a section through a human brain.



e) Identify the structures labelled **S**, **P**, **Q** and **R** from the figure above.

S = Cerebrum	(1)
P = Pituitary gland	(1)
Q = Medulla (oblongata)	(1)
R = Cerebellum	(1)
Total: 4 marks	

f) Describe the function of structure **S**.

Any two from the following:	
Controls memory / language / thought / intelligence	(1)
Controls consciousness / personality	(1)
Receives and processes information from senses	(1)
Total: 2 marks	

(Total for Question 7 is 17 marks)