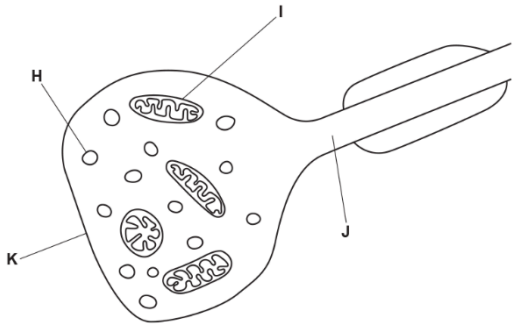
Synapses A02 Homework Questions

1. The image below shows a synaptic bulb.



Which of the following rows, **A** to **D**, correctly names the parts labelled **H** to **J** in the image?

	H	I	J	K
A	vesicle containing neurotransmitter	mitochondrion	dendron	postsynaptic membrane
B	vesicle containing Ca^{2+}	mitochondrion	axon	presynaptic membrane
C	vesicle containing Ca^{2+}	myelin	dendron	postsynaptic membrane
D	vesicle containing neurotransmitter	mitochondrion	axon	presynaptic membrane

Your answer ☐ **[1]**

2. Animals receive different stimuli from their environment. Their synapses can manage multiple stimuli, often resulting in one response (such as a muscle twitching).

This action of the synapse is an example of

A spatial summation
B all or nothing response

C temporal summation

D cell signalling

Your answer ☐

[1]

3. The table below shows the membrane potentials of different neurones at a cholinergic synapse.
The data were recorded on five separate occasions, as shown in the five rows.

	Membrane potential (mV)			
	Presynaptic neurone A	*Presynaptic neurone B*	*Presynaptic neurone C*	*Postsynaptic neurone*
1	+40	–70	–70	–70
2	–70	+40	–70	–70
3	–70	–70	+40	–70
4	+40	+40	–70	–70
5	+40	+40	+40	+40

Which of the following, **A** to **D**, explains these data?

A divergence

B hyperpolarisation

C spatial summation

D temporal summation

Your answer ☐ **[1]**

4. The table below lists a number of statements about the functions of neurones. Indicate whether each statement refers to:

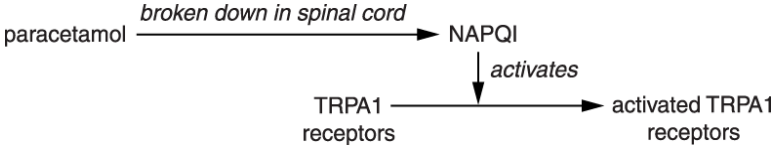
- sensory neurones only **(S)**
- motor neurones only **(M)**
- sensory **and** motor neurones **(B)**.

Statement	**S** or **M** or **B**
Have a resting potential of approximately –70 mV	B
Transmit nerve impulses from the CNS	
Connect to other neurones via synapses	
Connect to effectors	

[3]

5. Paracetamol is a drug that is commonly used as a painkiller. For many years, scientists have been uncertain about the way in which paracetamol works.
A recent study has shown that:

- paracetamol is broken down in the spinal cord into a compound called NAPQI
- NAPQI activates a receptor protein called TRPA1
- TRPA1 is found on the plasma (cell surface) membranes of neurones
- the activated receptor protein, TRPA1, interferes with the transmission of the nerve impulses from one neurone to the next.



i. Name **one** chemical that transfers a nerve impulse from one neurone to another.

[1]

ii. Suggest the part of the neurone where the plasma membrane has TRPA1 receptors.
Explain your answer.

part of neurone

explanation

[2]

6. Nicotine molecules have a shape that is complementary to acetylcholine receptors. As a result, nicotine interferes with the nervous systems of insects and mammals by binding with these receptors.

i. Where, precisely, are acetylcholine receptors found?

[1]

ii. The way that nicotine is thought to work is outlined in Fig. 7.1.

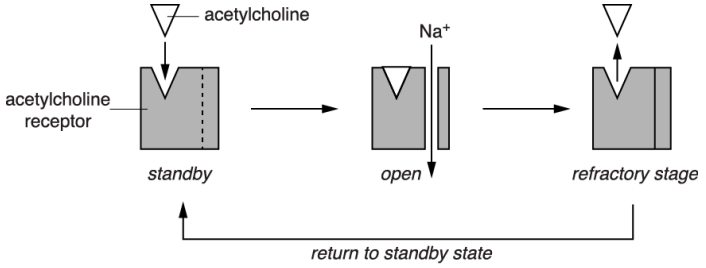


Fig. 7.1(a) When nicotine absent

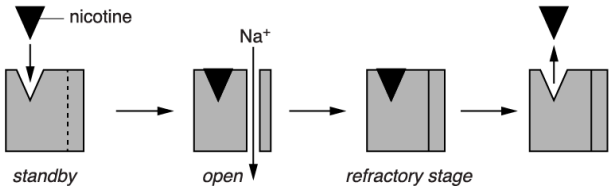


Fig. 7.1(b) When nicotine present

Using the information in Fig. 7.1(a) and Fig. 7.1(b), suggest and explain the effect that nicotine has on the nervous system.

[3]

7. Fig. 3.3 is a diagram representing the neuromuscular junction in mammals.

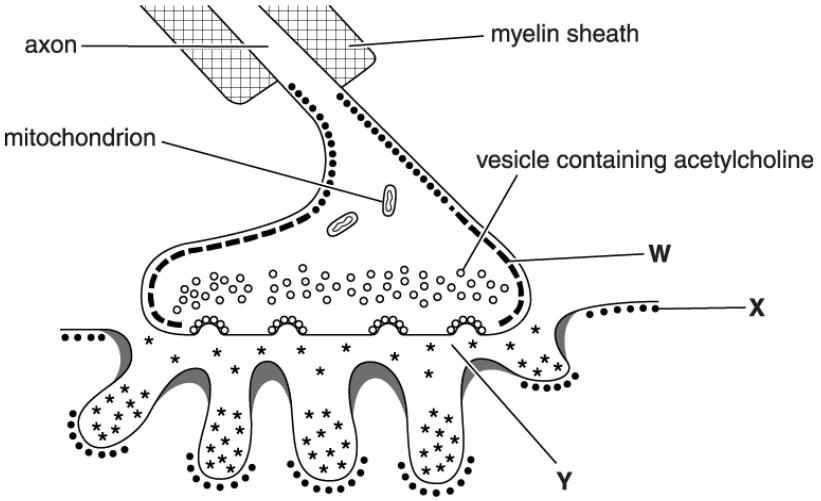


Fig. 3.3

i. What type of molecule forms ion channels **W** and **X**?

[1]

ii. Identify region **Y**.

[1]

iii. Name the enzyme found in region **Y**.

[1]

8. **GABA** (gamma-aminobutyric acid) is one of the most common neurotransmitters in the human central nervous system.

GABA is synthesised from the amino acid glutamate.

GABA acts as an **inhibitory neurotransmitter**.

When GABA binds to its receptor, a chloride ion channel is opened and chloride ions (Cl^-) enter the neurone.

Fig. 3.2 represents two neurones forming synapses with a third neurone.

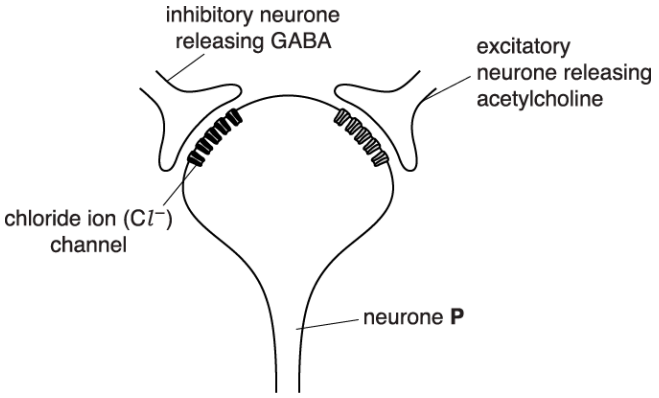


Fig. 3.2

Suggest how GABA is released from the inhibitory neurone **and**, using the information in Fig. 3.2, explain why an action potential may not occur in neurone **P** if both GABA and acetylcholine are released.

In your answer, you should make clear both the sequence of events in the release of the neurotransmitter and why an action potential could be prevented by GABA.

[6]

END OF QUESTION PAPER

Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			D ✓	1 (AO1.1)	
			Total	**1**	
2			A	1	
			Total	**1**	
3			C ✓	1	
			Total	**1**	
4			**M;** **B;** **M;**	3	**Mark the first answer in each box.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
			Total	**3**	
5		i	acetylcholine;	1	**Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **CREDIT** other correct examples e.g. dopamine / noradrenaline / norepinephrine **ACCEPT** ACh
		ii	***either*** post-synaptic membrane; (TRPA1) prevents attachment of (named) neurotransmitter to its receptor; ***or*** pre-synaptic membrane / (pre)synaptic knob / axon terminal / bouton / synaptic bulb : (TRPA1) prevents, release of (named) neurotransmitter / influx of calcium ions;	2	**Explanation must match correct location for 2 marks.** **If no location stated then explanation can be awarded independently for 1 mark.** **Incorrect location = 0 marks**. **IGNORE** 'interferes' (as in Q) **IGNORE** ref to dendrites / cell bodies / neurone(s) / synapse(s) **CREDIT** causes hyperpolarisation **DO NOT CREDIT** idea that TRPA1 is a free protein that will enter the ACh receptor and block it (rather like a or competitive inhibitor occupying the active site of an enzyme) **ACCEPT** Ca^{2+}
			Total	**3**	
6		i	postsynaptic membrane(s) (in, neurone / neuromuscular junction);	1	**ACCEPT** sarcolemma **DO NOT CREDIT** postsynaptic knob

		ii	*Effect* Nicotine slows down rate of / stops, transmission of, action potentials / nervous impulses; **Plus any 2 of the following:** *Explain* binds to receptor; (nicotine) has the same response / opens Na^+ channels / causes depolarisation; nicotine remains in receptor for longer; *idea that* receptor, remains in refractory stage for longer / unable to return to standby condition cannot be reactivated;	3 max	**IGNORE** 'nervous system slows down' / 'acts as a depressant' **ACCEPT** competes with acetylcholine for the receptor **DO NOT CREDIT** active site **DO NOT CREDIT** 'acts as competitive inhibitor' **DO NOT CREDIT** binds to receptor permanently **ACCEPT** causes action potential in next neurone / mimics, action / effects, of acetylcholine **IGNORE** 'mimics acetyl choline' alone **IGNORE** delays refractory stage **ACCEPT** permanently in refractory stage
			Total	**4**	
7		i	protein;	1	**ACCEPT** glycoprotein **IGNORE** polypeptide / channel / carrier / transport
		ii	(synaptic) cleft;	1	**IGNORE** gap **IGNORE** neuromuscular
		iii	acetylcholine esterase / ACh esterase;	1	**ACCEPT** phonetic spelling and ignore upper / lower case **IGNORE** AChE
			Total	**3**	

8			1. nerve impulse / action potential, causes, influx / AW, of calcium ions / Ca^{2+} (into pre-synaptic / inhibitory neurone); 2. (causes) vesicles to fuse / AW, with the pre-synaptic membrane and release GABA; 3. GABA diffuses across the synaptic cleft; 4. binds to (complementary) receptors on, post - synaptic neurone (membrane) / neurone P (membrane); 5. *idea that* influx / AW, of chloride (ions) makes, the post synaptic neurone / neurone P, more negative / hyperpolarised; 6. *idea that* (not enough sodium ions can enter so) the threshold potential not reached;	5	**DO NOT CREDIT** 'Calcium' or Ca+ but penalise **ONCE** only **ACCEPT** 'calcium enters' if **calcium ion** channels have been referred to **ACCEPT** a clear implication of inhibitory neurone **2. CREDIT** exocytosis of GABA **CREDIT** 'chloride ion channel' for receptor **ACCEPT** lower for negative ACCEPT a suitable value for threshold
				1	**mp 1,2 in that order plus mp 5 or mp 6** **Examiner's Comments** This question was split into two parts. Many candidates successfully described the sequence of events at the GABA synapse although some stated that it was the influx of chloride ions that was responsible for exocytosis. Weaker candidates made the same mistake seen in previous sessions when this topic was tested and implied that it is the vesicle that is released and diffuses across the synapse with some referring to seminal vesicles. Many candidates struggled with the second part of the question. Some answered in terms of competitive binding by GABA on acetylcholine binding sites despite information on how GABA affects the post-synaptic chloride ion channels. Some answered in terms of GABA or acetylcholine entering the post-synaptic neurone. Several candidates attempted to answer in terms of the effects of more negative ions inside the post-synaptic neurone but contradicted themselves by using the term hyperpolarisation when they meant depolarisation. However, there were some excellent responses where candidates explained that hyperpolarisation due to chloride ions meant the influx of sodium ions would be insufficient to achieve a threshold potential.
			Total	**6**	