Model Answers: Hard

1a

(a) An action potential is generated by a taste bud that responds to salty flavour as follows…

Any **three** of the following:

- An influx / the inward movement/diffusion of sodium ions causes the cell surface membrane (of the salt receptor) to depolarise; [1 mark]
- If the receptor potential is large enough, voltage-gated calcium channels open; [1 mark]
- An influx / inward movement of calcium ions causes vesicles containing neurotransmitter to move towards the cell surface/basal membrane; [1 mark]
- The neurotransmitter is released and generates an action potential in the (neighbouring) sensory neurone; [1 mark]

[Total: 3 marks]

The diagram in Fig. 1 provides you with some information here so you must be sure to provide more detail than the diagram. Make sure that you use the necessary key words.

1b

(b) An action potential is generated by a taste bud that responds to sweet flavours as follows…

Any **three** of the following:

- The G protein is activated; [1 mark]
- The (activated) G-protein activates the enzymes adenyl cyclase; [1 mark]
- Cyclic AMP/cAMP activates protein kinase A; [1 mark]
- (Protein kinase A) phosphorylates / adds phosphate groups to potassium channel proteins (causing them to close); [1 mark]
- Potassium ions (cannot leave the cell so) build up inside the cell; [1 mark]
- The build up of positive ions depolarises the cell; [1 mark]
- Depolarisation causes (voltage-gated) calcium ion channels to open; [1 mark]

[Total: 3 marks]

This is a slightly tricky question but there are many ways of gaining the three marks available. You need to apply your knowledge of the second messenger model of hormone action to this unfamiliar context, and Fig. 1 gives you plenty of clues. The sugar molecule causes a change in shape of the receptor, activating a G protein. The G protein activates the enzyme adenyl cyclase, which converts ATP into cyclic AMP (this is shown clearly in Fig. 1 so no mark is available for stating this). Cyclic AMP activates protein kinase A, which phosphorylates potassium ion channels. The potassium ion channels close, preventing potassium from leaving the cell and leading to a build up of positively charged potassium ions. This has the same effect as an influx of sodium ions in a salt receptor; the cell is depolarised, voltage-gated calcium ion channels open, and the rest of the events would then be the same as in part a).

1c

(c) Fig 2 shows the following about the effect of stimulus size on membrane potential…

- When a stimulus is below a certain size no action potential is generated / the threshold for an action potential is not reached / the membrane depolarisation is

small / the membrane depolarisation is proportional to the size of the stimulus; [1 mark]

- When a stimulus is above a certain size / above the threshold the membrane always depolarises by the same amount / the size of the action potential is always the same **OR** the size of a large stimulus has no effect on the size of the resulting action potential; [1 mark]

[Total: 2 marks]

Fig. 2 illustrates the all-or-nothing principle of action potential generation. The small stimuli all generate small amounts of membrane depolarisation; a slight difference in stimulus size at this level makes a small difference in depolarisation but all are below the threshold for an action potential. The larger stimuli do generate an action potential and the size of the original stimulus has no effect on the size of the action potential; when a stimulus size threshold is reached the size of the resulting action potential is always the same.

1d

(d) An action potential is transmitted along an axon as follows...

Any **three** of the following:

- Current flows / local circuits occur / sodium ions diffuse from the area of action potential to the next section of axon / to a section of axon at resting potential; [1 mark]
- Sodium ion channels (in the new section of axon) open / the membrane (in the new section of axon) depolarises; [1 mark]
- Hyperolarisation / the refractory period (in the previous section of axon) prevents the impulse from travelling backwards / ensures that the impulse travels in only one direction; [1 mark]
- In a myelinated neurone the axon is insulated / depolarisation cannot occur through the myelin / Schwann cells; [1 mark]
- (In a myelinated neurone) depolarisation can only occur at the nodes of Ranvier / at unmyelinated sections; [1 mark]
- (In a myelinated neurone) saltatory conduction occurs / the imulse jumps from one node to the next; [1 mark]

[Total: 3 marks]

Marks can be gained here for describing transmission of nerve impulses in either a non-myelinated or a myelinated neurone.

2a

(a) The percentage increase in impulse transmission speed in myelinated neurones when the axon diameter is increased from 7 μm to 16 μm is...

- 9 ÷ 27; [1 mark]
- 33.3 (%); [1 mark]

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

[Total: 2 marks]

The equation for calculating percentage increase is:

$$\text{percentage increase} = \frac{\text{change}}{\text{starting point}} \times 100$$

find the relevant numbers in table 3.1

Neurone source	Myelinated	Axon diameter / μm	Speed of impulse transmission / m s^{-1}
Cat	Yes	5	27
Rabbit	No	7	6
Frog	Yes	16	36
Newt	Yes	7	27

myelinated neurones

axon diameter at 7μm and 16μm

transmission speeds

calculate the change in transmission speed:

because you are calculating the percentage increase the lowest number is the starting point

$36 - 27 = 9$

substitute numbers into equation:

$$\text{percentage increase} = \frac{9}{27} \times 100$$

[1 mark]

$$= 33.3\ (\%)$$ [1 mark]

2b

(b) The effect of myelination on neurones is...

- Myelination increases conduction speed / speed of impulse transmission; [1 mark]
- The unmyelinated (rabbit) axon transmits impulses at 6 m s^{-1} and the myelinated (newt) axon transmits impulses at 27 m s^{-1}; [1 mark]

[Total: 2 marks]

Note that the data to support the description comes from two axons of the same diameter; this means that any differences in speed of impulse transmission must be due to myelination.

2c

(c) (i) Myelination affects the speed of nerve transmission because…

Any **three** of the following:

- Transport of ions cannot take place through the myelin sheath / Schwann cells **OR** myelin insulates the axon; [1 mark]
- Action potentials can only be generated at gaps between the myelin sheath / Schwann cells / at the nodes of Ranvier; [1 mark]
- Between the nodes/gaps sodium ions diffuse along the axon / currents flow / local circuits occur; [1 mark]
- (This leads to) saltatory conduction / the impulse appearing to jump between nodes (which is much faster than the transmission in an unmyelinated neurone); [1 mark]

Saltatory conduction involves the impulse appearing to jump from one node to the next; this occurs due to the diffusion of sodium ions inside the axon within the myelin sheath (know as local circuits). In an unmyelinated neurone the impulse is transmitted by the continuous process of diffusion, depolarisation, channel opeing, and sodium influx; this is much slower than the local circuits that occur within the myelin sheath.

(c) (ii) Axon diameter affects the speed of nerve transmission because…

Any **one** of the following:

- Wider axons have a larger (membrane) surface area across which ion transfer can take place; [1 mark]
- Ions diffuse into wider axons at a faster rate, creating a steeper concentration gradient within the axon (leading to faster diffusion); [1 mark]

[Total: 4 marks]

2d

(d) Evaluative points regarding the conclusion that there is a relationship between myelin content and dementia include…

In support of the conclusion:

- Patients with both types of dementia had less myelin than the control group **OR** the control group had higher myelin content than patients with both types of dementia; [1 mark]
- Differences between groups are (statistically) significant (as standard deviations do not overlap); [1 mark]
- The conclusion states correlation/relationship but does not conclude causation / that lack of myelin causes dementia; [1 mark]

Against the conclusion:

A maximum of **three** of the following:

- There are large/significant differences in myelin content between different types of dementia (suggesting that other factors may be involved); [1 mark]

- Small sample sizes are not representative of the population (as a whole) **OR** the sample sizes are too small to apply to the rest of the population; [1 mark]
- These results come from a single study **OR** more data is required (to be sure of the conclusion); [1 mark]
- Not all / only two forms of dementia were included in the study; [1 mark]

[Total: 4 marks]

The command word for this question is **evaluate** so you need to address both sides of the argument. Be sure to use the data itself, but it is also always a good idea to consider any statistical analysis provided, as well as the design of the investigation.

3a

(a) (i) The missing cell in Table 1 is...

- 0.13 (seconds); [1 mark]

$$\text{reaction time} = \sqrt{\frac{2 \times D}{g}}$$

D = distance ruler had dropped in metres
$g = 9.8\,\text{m s}^{-2}$

Student 4 caught the ruler in 0.08m
so the calculation required is:-

Reaction time $= \sqrt{\frac{2 \times 0.08}{9.8}} = 0.127\,\text{s}$

You can round to 2dp because the rest of the reaction times are shown to that level of precision

$= 0.13\,\text{s}$ [1 mark]

(a) (ii) A prediction of what would happen to the reaction time if the ruler was held higher than the original set height is...

Any **one** of the following:

- The reaction time would be unchanged; [1 mark]
- The reaction time would be longer/slower; [1 mark]

[Total: 2 marks]

The first answer (reaction time unchanged) is acceptable because a person reacts to the visual stimulus of the ruler beginning to move. Therefore the height from which the ruler is

dropped won't affect a person receiving a visual stimulus. An unknown is that the question does not specify how much higher the ruler would start from.

The second answer (longer reaction time) is also plausible in that if the ruler is falling from a greater height, it will be travelling faster by the time student A catches it, so he/she will have to 'time' their catch to a point when the ruler has fallen to a point that is within their grasp (assuming student A keeps their hand firmly on the bench, as they should).

In our opinion this question can also be answered correctly in a third way, i.e. that the reaction times appear to get shorter. If a person catches the ruler at D=10 cm when it starts falling from D=0, then you can reasonably expect that person to catch it at D=8 cm if it starts 2 cm higher up at D=-2 cm. D=8 would give a lower reaction time when worked through the formula.

However, the exam board only chooses to credit two possible answers (for reasons that we at Save My Exams are unsure of), as shown above.

3b

(b) (i) The dependent variable in this investigation is...

- The distance that the ruler drops/falls; [1 mark]

(b) (ii) A method that the students could use to find out if the presence or absence of background noise affects reaction time is...

Any **seven** of the following:

- To test in silence/quiet **AND** with background noise; [1 mark]
- A method to ensure silence is outlined e.g. using a sound-proofed room; [1 mark]
- A method to ensure consistent loudness OR volume of noise is outlined e.g. decibel meter readings; [1 mark]
- A suitable number of people are tested OR more than one person tested; [1 mark]
- No warning should be given when ruler is to be dropped; [1 mark]
- *Outline of the ruler used:* same ruler mass OR material OR starting distance OR ruler held vertically; [1 mark]
- Person being tested is the same/similar age OR same sex; [1 mark]
- The person being tested should use their same / their dominant hand; [1 mark]
- The person being tested should not be taking (named) drugs / medications / stimulants / depressants; [1 mark]
- The person being tested should not have with conditions affecting reaction time e.g. poor hearing / poor sight / neurological disorders; [1 mark]
- The tests should take place at the same time of day OR at a stated time; [1 mark]
- A minimum of three repeats carried out **and** a mean calculated; [1 mark]
- The experiment carries low OR medium risk; [1 mark]

It is not enough to just copy out the basic procedure here. Some thought is required as to how the conditions of noise and no noise can be achieved. Also, an appreciation of the risk should be made, for example the risk to hearing if the noise is played at an excessive volume.

More that one subject is required because different people will have naturally different reaction times. Make sure to mention that no warning should be given before the ruler is dropped; that is one mark that many students miss out on.

Many students go into unnecessary detail about control variables that have nothing to do

with the outcome of the investigation. For example, using the 'same bench' or 'constant wind speed' are unlikely to be factors that affect the outcome, in that wind speed indoors is usually zero and that most (lab) benches are built at a standard height.

Finally, when discussing averages, make sure to state which measure of average is calculated; in these tests, it is usually the mean.

[Total: 8 marks]

3c

(c) A bar chart is a suitable way to show the data because...

Any **one** of the following:

- (The independent variable is) discontinuous; [1 mark]
- (The independent variable is) discrete; [1 mark]
- (The independent variable is) qualitative; [1 mark]
- (The independent variable is) categoric; [1 mark]
- There are only two scenarios of noise / on or off / present or absent; [1 mark]

[Total: 1 mark]

Avoid vague terms like 'a bar chart shows the data more clearly' as this will not score the mark. You need to relate the choice of bar chart to the fact that the independent variable (shown on the x-axis) is categoric.

3d

(d) (i) One conclusion that the students could have made based on these results is...

Any **one** of the following:

- That the absence of noise means that reaction time is longer; [1 mark]
- That the presence of noise means that reaction time is shorter; [1 mark]

(d) (ii) A *t*-test is suitable for these data because...

- A *t*-test is designed for comparing (two) means / of continuous data / that follow a normal distribution; [1 mark]

(d) (iii) A null hypothesis for this test is...

- That there is no (significant) difference between the (mean) reaction times for no (background) noise and (background) noise; [1 mark]

(iv) What the value of *t* indicates about the difference in mean reaction times shown in Fig. 3 is...

- (That the difference is) not significant / is due to chance (at $p > 0.05$) **AND** because the calculated value / 2.05 is less/lower than the critical value of *t*/2.12; [1 mark]

degrees of freedom	10	12	14	16	18	20	22	24	26	28	30	40	50	60
probability 0.05	2.23	2.18	2.14	2.12	2.10	2.09	2.07	2.06	2.06	2.05	2.04	2.02	2.01	2.00

(iv) The students used 16 degrees of freedom and calculated $t = 2.05$.

16 degrees of freedom gives a critical value of 2.12
This is above the calculated value of t (2.05) so the results are likely to have been achieved by chance.
The null hypothesis can therefore be accepted.

[Total: 4 marks]

3e

(e) (i) The independent variable in this experiment is...

- The number of repeats/attempts at the task; [1 mark]

Remember, the independent variable (I.V.) is the thing that the experimenters change deliberately to examine the effect of those changes on something else. In this case, the experimenter is looking to see the effect of the number of times a person has attempted a task on how accurately they complete the task. So the I.V. is the number of attempts made by an individual.

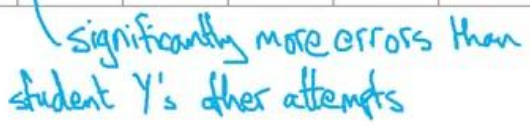
(e) (ii) A suggestion of the hypothesis that was tested in this experiment would be...

- As the number of attempts increases, the accuracy of completing the task increases / number of errors decreases; [1 mark]

(e) (iii) The result in Table 3 that was affected by a person walking into the room and talking to one of the students was as follows...

Award 1 mark for a **circle** around the correct answer as follows:

student	number of times the students' lines went outside the double lines of the star								
	1	2	3	4	5	6	7	8	9
V	48	48	46	44	42	40	41	41	41
W	45	42	43	40	38	35	36	35	35
X	38	37	34	32	31	30	28	28	28
Y	31	30	31	29	44	28	26	25	25
Z	41	40	38	37	35	35	33	33	32



Be careful to read what the question is asking you to do; you may feel that the question is asking you to name the student that was affected when somebody walked into the room, so circling 'Y' or even the whole row will lose you this mark. The question states clearly that you should circle just one result.

(e) (iv) The student who had previously carried out a similar task was...

- Student Y

This is because...

Any **one** of the following:

- Y made fewer errors / was more accurate; [1 mark]
- Y started off with fewer errors / was more accurate from the start/attempt 1; [1 mark]

This has nothing to do with the fact that Student Y was disturbed during the experiment. That is just a coincidence.

[Total: 4 marks]

3f

(f) Two conclusions based on the data in Table 3 are...

Any **two** of the following:

- The more replicates/repeats that are carried out, the more accurate / the fewer errors are made; [1 mark]
- After 6–7 / several trials, the number of errors starts to plateau / the number of errors does not continue to decrease; [1 mark]
- Interruptions/distractions increase number of errors; [1 mark]

[Total: 2 marks]

The first marking point is easier to gain that a second; the data shows that the increase in accuracy tails off after a number of attempts, so it is important to capture that, rather than to state merely that 'accuracy varies'.