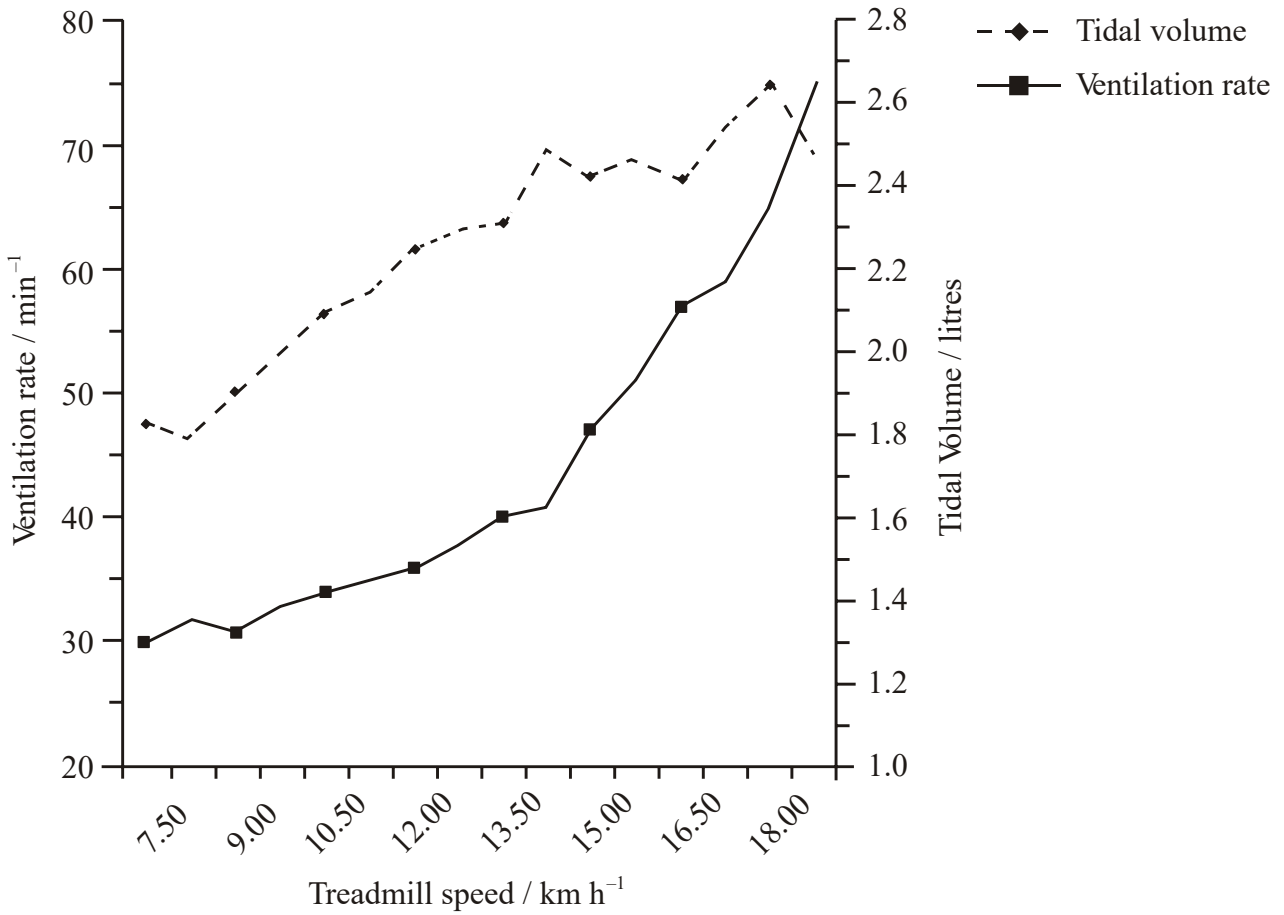


TOPIC 7 – BODY SYSTEMS

Ventilation (7 marks)

As intensity of exercise increases, humans respond to the increased need for gas exchange in two ways: by varying ventilation rate and tidal volume. Experimental data for a runner on a treadmill are shown below.



a. Outline the relationship between treadmill speed and tidal volume. (2 marks)

i. up to 14 km h^{-1}

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ii. above 14 km h^{-1}

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b. Compare the trend in ventilation rate with the trend in tidal volume at a high treadmill speed. (1 mark)

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c. Calculate the total volume of air inhaled per minute when the treadmill speed is 15 km h⁻¹. (2 marks)

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d. Suggest how the ventilation rate and tidal volume might alter if treadmill speed were increased even further. (2 marks)

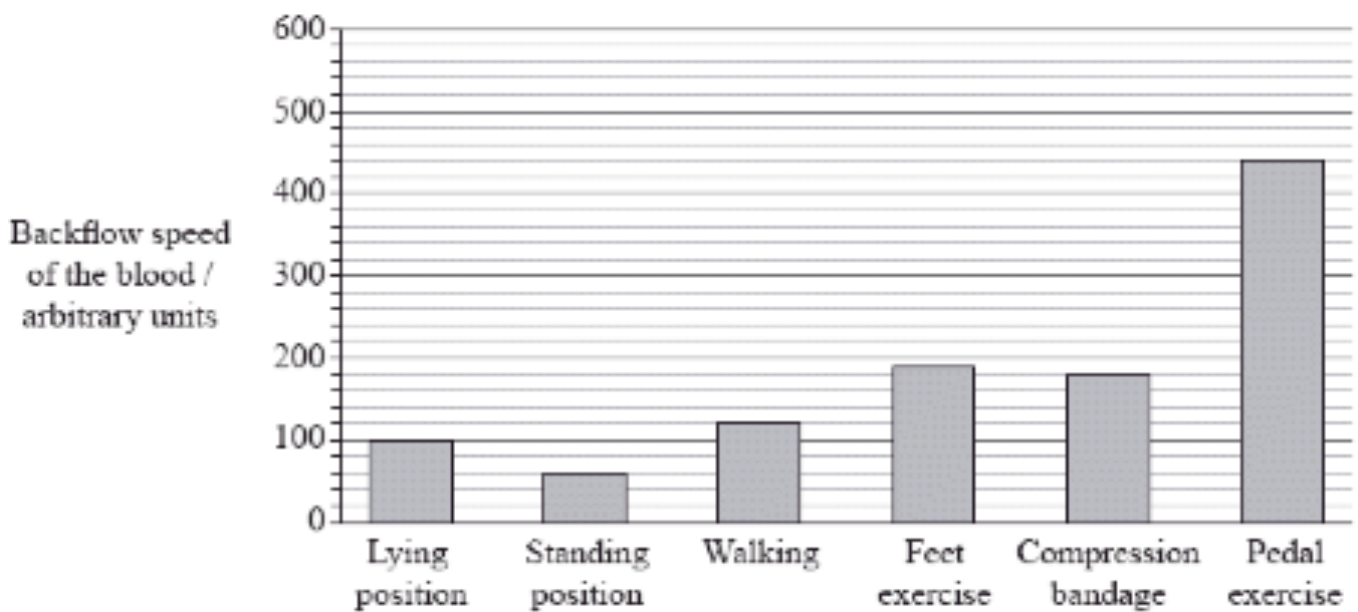
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Blood Flow (7 marks)

Backflow is the return of blood to the heart. In legs, backflow is enhanced by the pumping action of leg muscles during movement. When this does not occur efficiently, serious health problems can arise. The backflow speed of 40 patients was measured during the application of different therapy methods. The lying position is the control.



a. State which activity reduces backflow speed in relation to the control. (1 mark)

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b. Suggest a reason why backflow speed is reduced by the activity stated in part a. (1 mark)

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c. Determine the difference in backflow speed between the lying position and pedal exercise. (1 mark)

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d. Discuss the benefits of exercising to promote high backflow speed. (3 marks)

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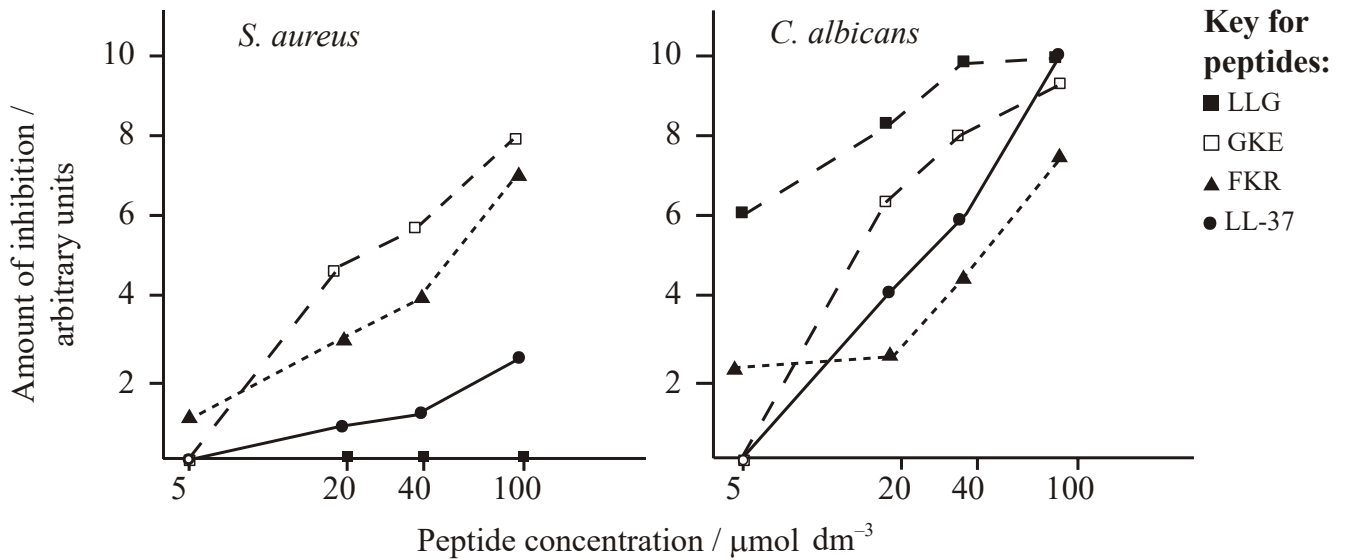
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Antibiotics (7 marks)

Antibiotic peptides occur naturally on the surface of human skin. One of these peptides, called LL-37, and three other similar synthetic peptides were investigated to assess both their antibiotic properties and effect on human cells.

The graphs show the antibiotic effect of the peptides against two microbes, *S. aureus* and *C. albicans*. The technique involves measuring the inhibition of growth of the microbes.



a. Describe the effect of the FKR on *C. albicans*. (2 marks)

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b. Compare the effects of the peptide LLG on *S. aureus* and *C. albicans*. (2 marks)

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c. Evaluate the effectiveness of LL-37 against the two microbes. (3 marks)

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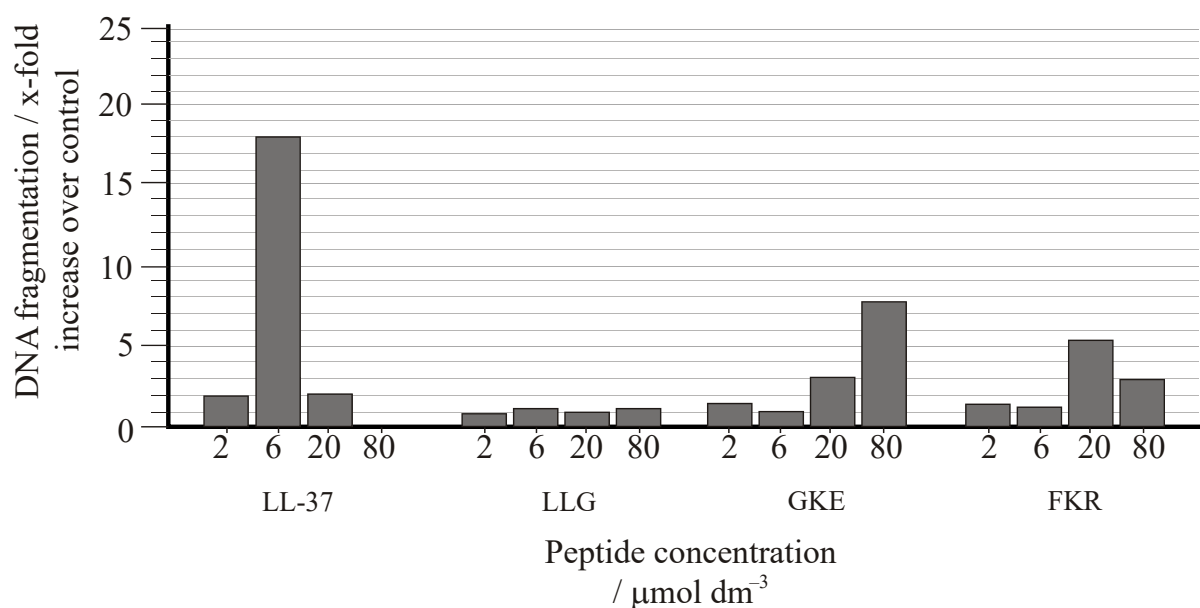
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There is concern that the peptides could damage living human cells. One form of damage is fragmentation of DNA. Human cells were incubated for 16 hours with each peptide at varying concentrations. The amount of DNA fragmentation was measured.



d. State which peptide causes the least damage to DNA. (1 mark)

.....

e. Calculate the percentage increase in DNA damage that results when the concentration of LL-37 increases from 2 mmol dm⁻³ to 6 mmol dm⁻³. Show your working. (2 marks)

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f. Discuss the hypothesis that synthetic peptides are most suitable for controlling *S. aureus* infection inside the human body. (4 marks)

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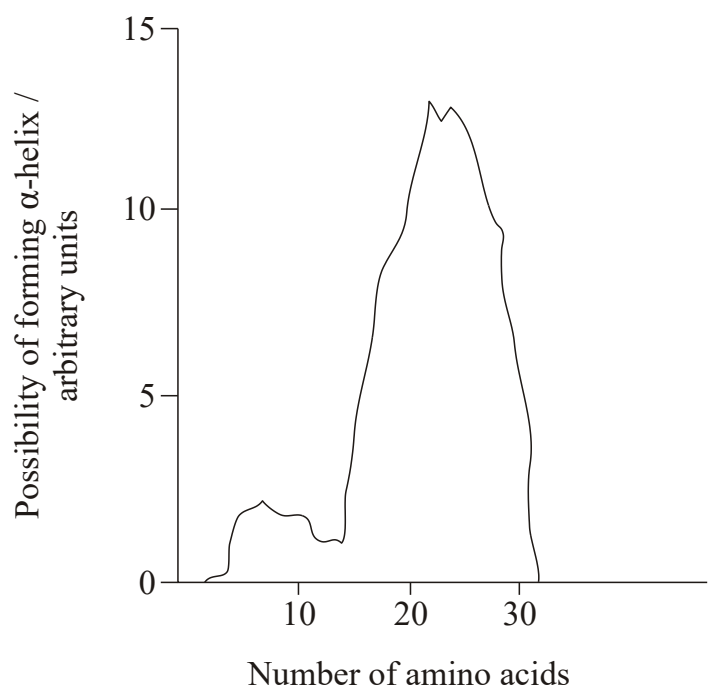
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The shape of the secondary structure of a peptide can be predicted from its amino acid composition. The figure shows the theoretical likelihood of the peptide LL-37 forming an α -helix, based on the properties and position of its 37 amino acids.



g. In addition to the α -helix, state a type of shape formed as the secondary structure of proteins. (1 mark)

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h. Analyse the data to determine the region of LL-37 most likely to form a helical shape. (2 marks)

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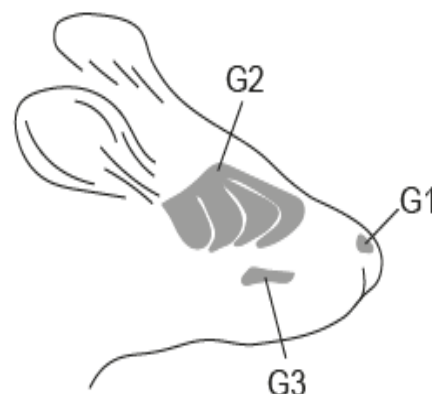
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i. Draw and label the structure of a peptide bond between two amino acids. (2 marks)

Alarm Compounds (9 marks)

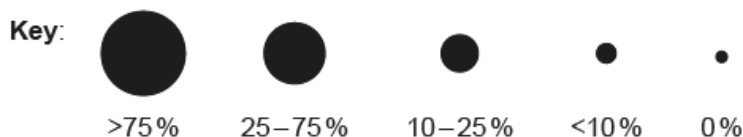
Mice have various defence systems against predators such as foxes or stoats. The mice release specific alarm compounds when under threat that serve as danger signals for other mice. Predators also release scents that the mice can detect.

In one study, mice were exposed to paper soaked in compounds taken from other mice, foxes or stoats in a test chamber. The scientists then measured the reaction of three different groups of neurons used in smelling: G1, G2 and G3, as shown in the diagram.



The percentage of G1, G2 and G3 neurons responding to the mouse, fox and stoat compounds, as well as a control compound, are shown in the chart.

	Mouse alarm compound	Fox scent	Stoat scent	Control
G1	●	●	●	●
G2	●	●	●	●
G3	●	●	●	●



a. State the percentage of G2 neurons in the mice that respond to the fox scent. (1 mark)

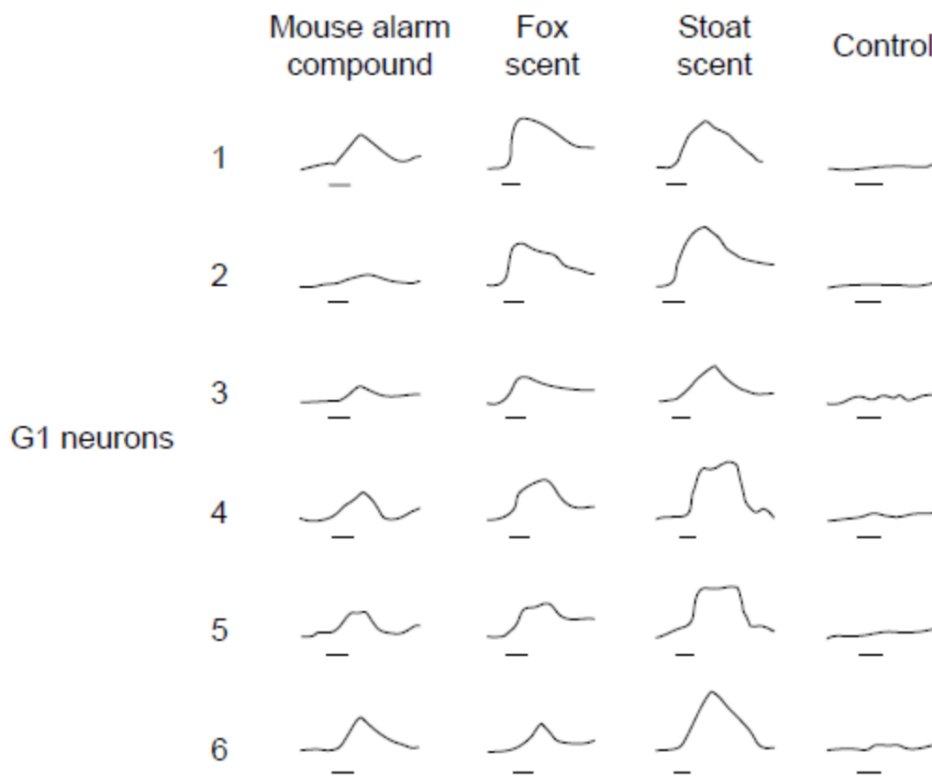
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b. Using evidence from the chart, identify, giving a reason, which group of neurons responded most to the chemicals. (1 mark)

.....

.....

The scientists recorded the neural traces (action and resting potentials) of six G1 neurons exposed to the compounds from the different animals. The horizontal bar beneath each trace corresponds to the time of exposure to the test compound.



c. State the name of the instrument used to make these traces. (1 mark)

.....

d. Distinguish between the effects of the mouse alarm compound and the effects of the control compound on the G1 neurons. (1 mark)

.....

.....

.....

e. Compare and contrast the effects of the alarm compound and stoat scent on the G1 neurons. (2 marks)

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f. Deduce whether there is a correlation between the neural traces and the percentage of responding G1 neurons. (2 marks)

.....

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.....

g. The molecular structures of the mouse alarm compound and fox scent are very similar. Suggest an evolutionary advantage for this chemical similarity. (1 mark)

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Answers

1a (2 marks)

- as treadmill speed increases, tidal volume increases
- at high treadmill speeds, tidal volume begins to level off / rate of increase slows

1b (1 mark)

ventilation rate continues to increase while tidal volume decreases / levels off

1c (2 marks)

- ventilation rate \times tidal volume
- 116 L \pm 4 L

1d (2 marks)

- ventilation rate would increase (until a physical limit was reached)
- tidal volume would level off / decrease / physical limit would be reached

2a (1 mark)

standing position

2b (1 mark)

- leg muscles are not pumping/contracting to help return of blood to the heart
- gravity pulls the blood back towards feet / circulation must overcome gravity to return blood to heart

2c (1 mark)

340 (arbitrary units)

2d (3 marks)

- better oxygenation enhances muscle metabolism
- better blood flow/cardiovascular fitness prevents pooling/swelling of ankles and feet/varicose veins
- prevention of thrombosis
- maintenance of muscle strength from better circulation
- maintenance of muscle strength from use of muscles

3a (2 mark)

- at lower concentration inhibition is low
- as concentration rises from 5–20 $\mu\text{mol dm}^{-3}$ there is very little increase in inhibition
- from 20 $\mu\text{mol dm}^{-3}$ inhibition increases in a linear manner
- a valid comparison with another of the peptides

3b (2 marks)

- no effect on *S. aureus*, inhibits growth of *C. albicans*
- no change on *S. aureus* as concentration increases, inhibition of *C. albicans* increases with concentration

3c (3 marks)

- at lowest (experimental) concentration (LL-37) does not have effect on either
- as concentration increases so does inhibition
- greater inhibition of *C. albicans*
- effective against *C. albicans* but not / less effective on *S aureus*

3d (1 mark)

LLG

3e (2 marks)

- $18 - 2 = 16 / 8 \times 100\% = 200\%$
- 800%

3f (4 marks)

- LLG / naturally occurring peptide less effective
- LL-37 less effective than GKE / FKR
- LL-37 damages DNA (significantly) at more than $6 \mu\text{mol dm}^{-3}$
- LL-37 may kill cells at higher concentrations
- GKE / FKR could be used at lower concentrations
- GKE / FKR cause slight DNA damage at lower concentrations
- GKE is (slightly) more effective
- GKE causes increased DNA fragmentation at higher concentrations

3g (1 mark)

β -sheet / β -pleat

3h (2 marks)

- sharp peak, strong chance around 20–25
- smaller peak, strong chance at around 4–6
- no likelihood above 32 / 33 / at end of molecule
- appropriate description. eg chance increases from 13 / 14 to 20 / 25

3i (2 marks)

- dipeptide showing N terminal and C terminal ends as well as a hydrogen and an R group attached to each α carbon
- a link between the carbon of the C=O group of one amino acid and the nitrogen of the N-H of the other correctly labelled

4a (1 mark)

10–25%

4b (1 mark)

- G1 always respond more than 25% «except control», while G2 and G3 always respond 25% or less
- G1 always responds more than G2 and G3/all of the others (OWTTE)

4c (1 mark)

Oscilloscope

4d (1 mark)

mouse chemicals cause action potentials in all neurons while controls cause none/mouse chemicals cause greater responses

4e (2 marks)

- both chemicals cause action potentials **OR** both chemicals respond in the majority of/five/most neurons
- stoat scent causes a higher action potential/longer/bigger response than mouse alarm compound «in each neuron» **OR** neuron 2 reacts strongly to the stoat scent but has a minimal/no response to the mouse alarm compound

4f (2 marks)

- there is a positive relationship/correlation between the size of neural traces and the percentage of responding G1 neurons **OR** the chemicals that cause stronger/higher neural traces also cause the greatest percentage of responding G1 neurons
- fox and stoat scents have «roughly» the same/similar neural traces and the same percentage of responding neurons/>75 %
- mouse alarm compounds cause smaller neural traces and smaller percentage of responding neurons/25–75 %
- control chemicals have no response in both cases **OR** no percentage of «G1 neurons» response and no action potential

4g (1 mark)

- the mice would have the same response to another mouse's danger signal as to the actual presence of the predator/fox
- adaptation to fool predator by producing a scent similar to predator's own scent
- allows a group response to a predator/fox/danger when just one mouse detects the danger

Allow any feasible answer