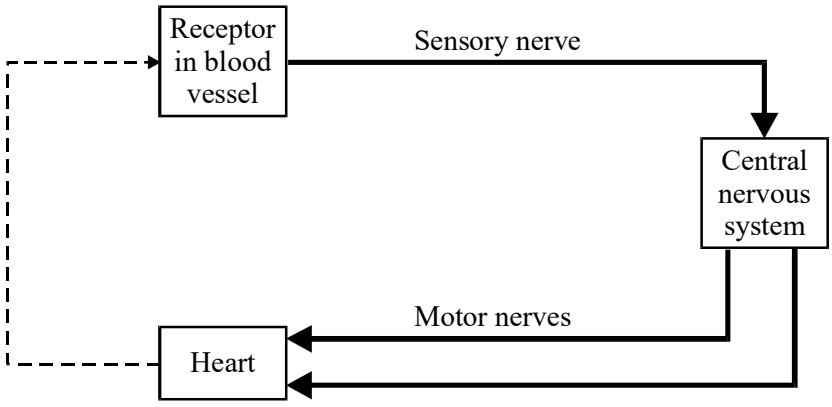
1. (a) The diagram shows how the heart rate is controlled.



(i) What stimulates the receptor?

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(1)

(ii) Where in the central nervous system is the heart rate control centre?

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(1)

(iii) Describe the part played by the motor nerves when the heart rate increases during a period of exercise.

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(2)

(iv) Use the diagram to explain how negative feedback would operate in the control of heart rate.

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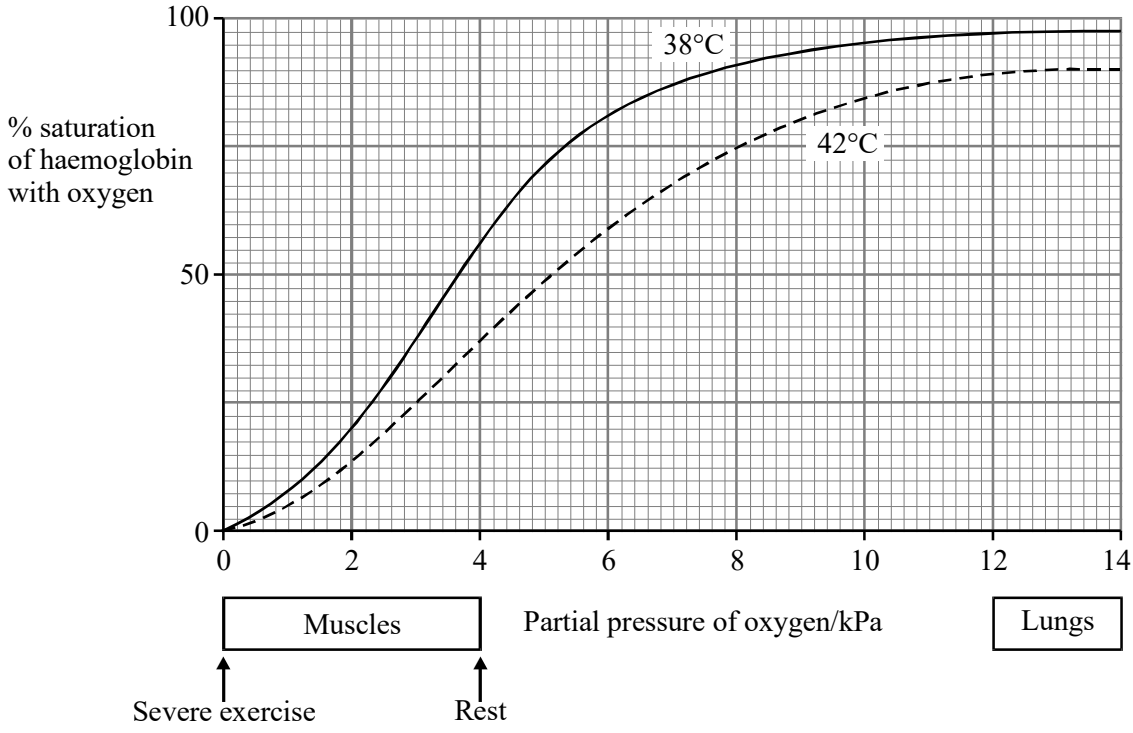
(2)

(b) The graph shows the effect of oxygen concentration on the saturation of haemoglobin at two different temperatures.



(i) Describe the effect of the increase in temperature on the percentage saturation of haemoglobin with oxygen.

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(1)

(ii) Using only the information in the graph, explain the ways in which severe exercise would cause an increase in the amount of oxygen available to the exercising muscles.

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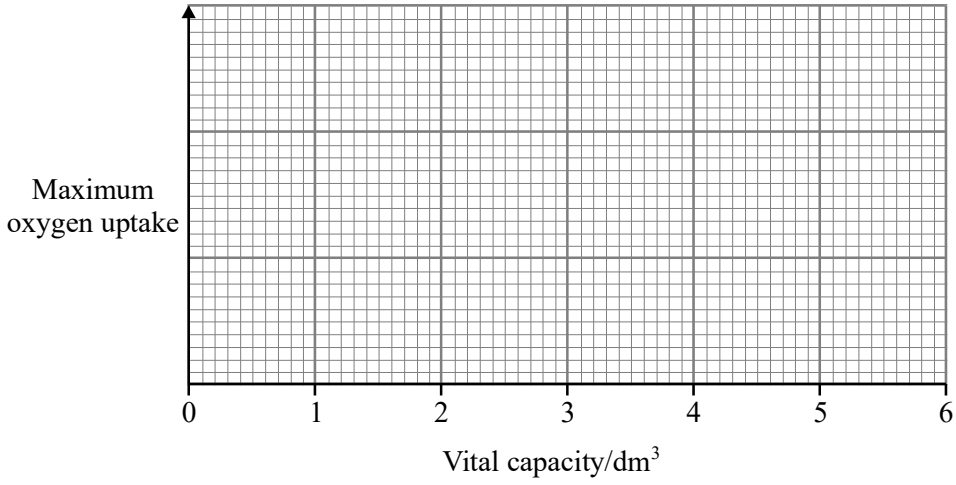
(4)

(c) Vital capacity in humans varies from 1.5 dm^3 to 6 dm^3. Individuals with different vital capacities exercised at maximum levels and their oxygen uptake was measured. A very high positive correlation between vital capacity and oxygen uptake was found.

(i) On the axes below sketch an example of the scattergram that would result.



(2)

(ii) What is the biological reason for the very high positive correlation between vital capacity and oxygen uptake?

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(1)

(d) In an investigation involving 40 female squash players, half were given an orange drink and half were given the same orange drink to which a small quantity of caffeine had been added. They all then played in a squash tournament. Throughout the tournament the lactate concentrations in the blood and the heart rate were measured. After the tournament their urine adrenaline concentration was measured and the players were asked to score their 'energetic drive' in the last half-hour of the tournament. The results are shown in the table.

Measurement	Without caffeine	With caffeine
Mean blood lactate/ mmol dm^{-3}	1.6	1.6
Mean heart rate/ beats per minute	141.0	140.0
Urine adrenaline/ mmol dm^{-3}	1.0	2.0
'Energetic drive' arbitrary units (0 - 10)	5.1	8.8
Games won	21	28

Use the data to suggest how caffeine improved the performance of the squash players.

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(3)

(e) (i) Suggest why a dietary supplement of creatine might help players in sports, such as sprint running, where very demanding physical activity is required for a short time.

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(2)

(ii) Suggest why a dietary supplement of creatine might be more important for sprinters who are vegetarians, rather than for sprinters who are not vegetarians.

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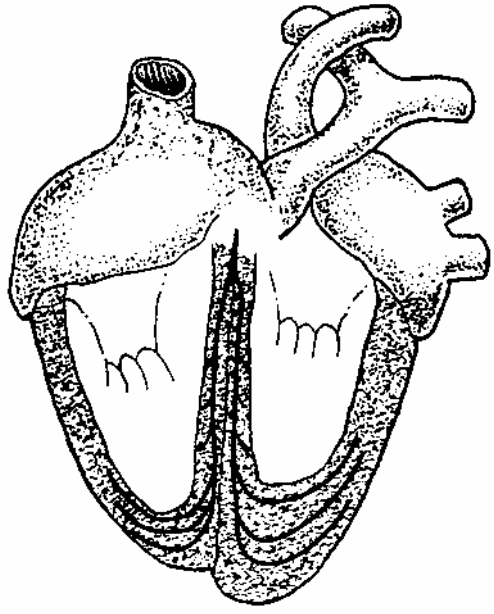
(1)

(Total 20 marks)

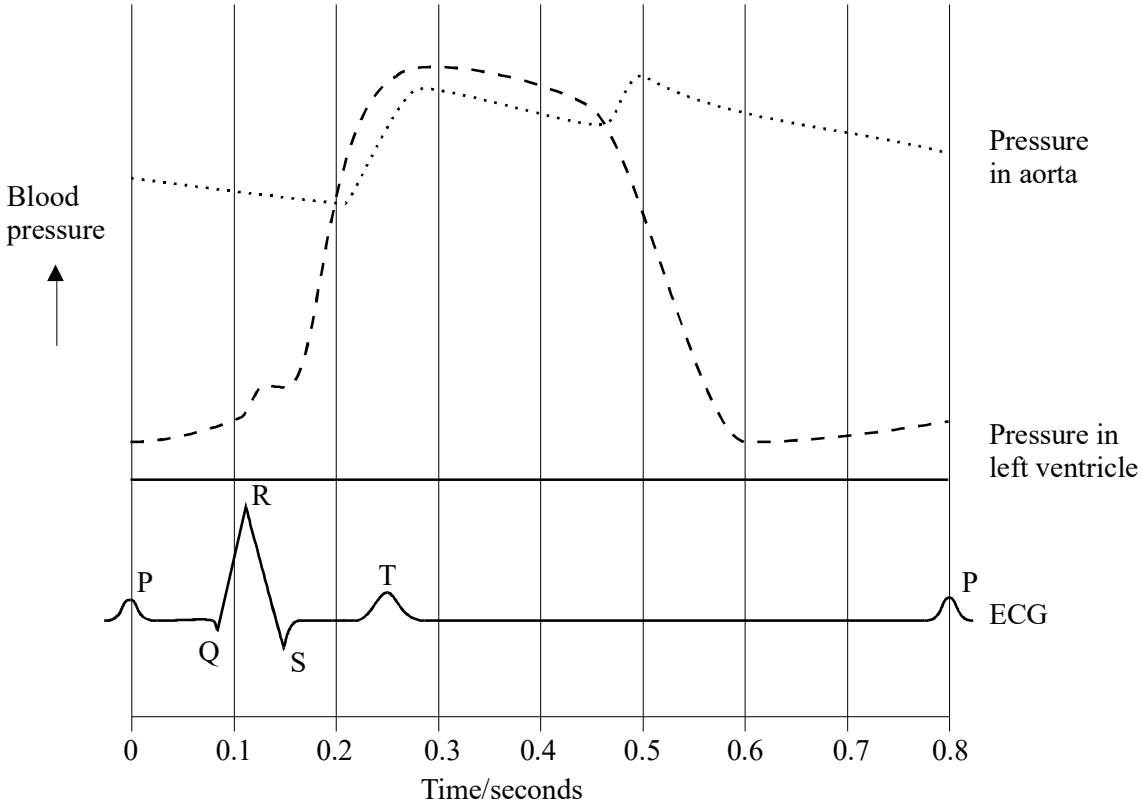
2. The diagram shows a human heart



(a) On the diagram, label the position of the atrioventricular node.

(1)

An electro-cardiogram (ECG) is produced by placing electrodes on the chest to detect electrical changes in the heart.
The diagram shows an ECG and the pressure changes during a human cardiac cycle.



(b) (i) The QRS wave is associated with the spread of electrical activity over the ventricle. Explain the evidence in the graph which supports this.

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(2)

(ii) Explain why there is no change in the electrical activity between 0.31s and 0.77s.

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(1)

(c) (i) At what time in the cardiac cycle does the aortic semilunar valve open?

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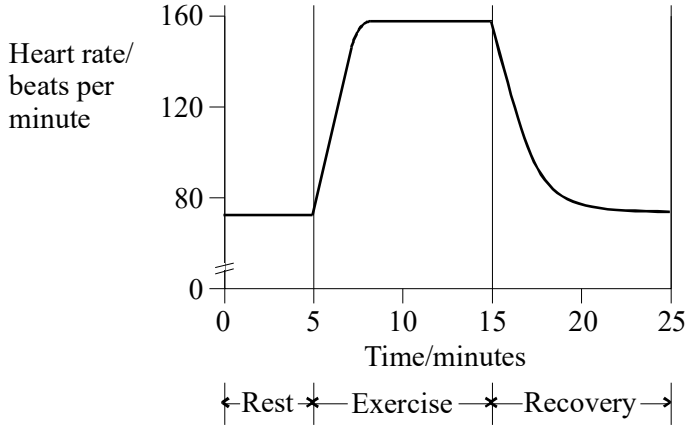
(1)

(ii) The pressure changes shown in the diagram are on the left side of the heart.
Sketch a curve on the graph to show the pressure changes in the right ventricle.

(2)
(Total 7 marks)

3. The graph shows the heart rate before, during and after exercise.



(a) Explain how the nerves connected to the heart cause the changes seen during

(i) the first 2 minutes of exercise;

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(ii) the recovery period.

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(4)

(b) The cardiac output is the amount of blood one ventricle pumps out per minute. The table shows the percentage of the cardiac output distributed to various organs when the body is at rest.

Organ	Percentage of cardiac output at rest
Bone	5
Brain	15
Heart	5
Kidneys	25
Liver	15
Skin	5

(i) At rest the amount of blood pumped out by a single contraction of one ventricle is 70 cm^3 and the mean heart rate is 72 beats per minute. Calculate the total volume of blood supplied to the brain per minute.

Show your working.

Answer = ...

(2)

(ii) Prolonged training often results in a decrease in the resting heart rate although the cardiac output remains the same. How is this decrease achieved?

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(1)

(Total 7 marks)

4. Although the heart does have a nerve supply, the role of the nervous system is not to initiate the heartbeat but rather to modify the rate of contraction. The heart determines its own regular contraction.

(i) Describe how the regular contraction of the atria and ventricles is initiated and coordinated by the heart itself.

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(5)

(ii) Describe the role of the nervous system in modifying the heart rate in response to an increase in blood pressure.

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(5)

(Total 10 marks)

5. The sinoatrial node in the heart controls the heartbeat. The rate of heartbeat is coordinated by the brain.

(a) Name

(i) the two types of nerves that connect the brain to the sinoatrial node;

1.....

2.....

(2)

(ii) the part of the brain where these nerves originate.

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(1)

(b) Suggest

(i) why it is necessary to have two separate nerve connections from the brain to the sinoatrial node;

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(1)

(ii) how the two nerve connections are able to have different effects on the sinoatrial node.

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(2)

(Total 6 marks)

6. (a) Explain how the connections of rod and cone cells with neurones in the retina give rise to differences in

(i) sensitivity;

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(ii) acuity.

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(3)

(b) Explain why a person may be unable to see a dim star when looking straight at it, but can see it 'out of the corner of the eye'.

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(2)

(Total 5 marks)

7. **Figure 1** shows a Pacinian corpuscle and its sensory neurone which are present in the skin of a fingertip.

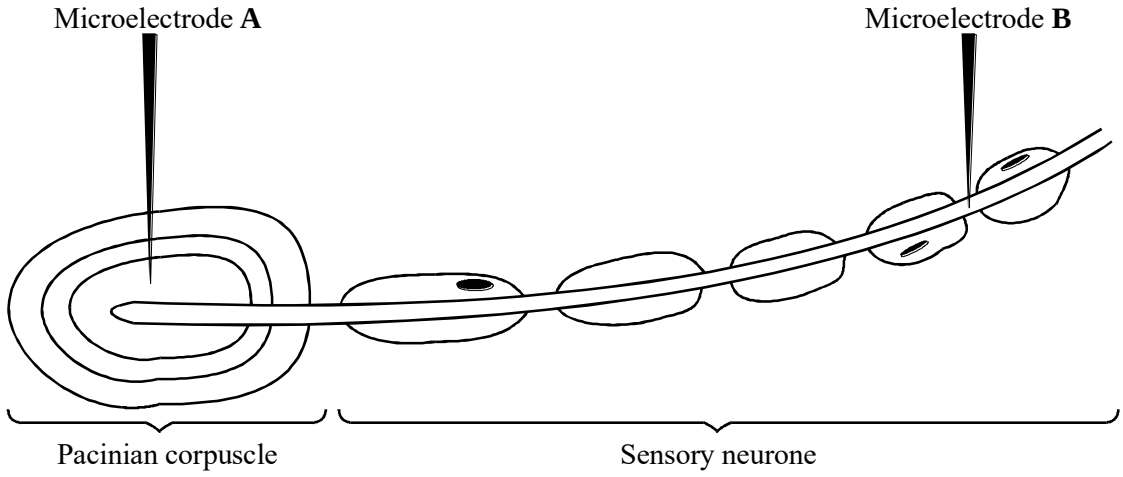

Figure 1

Figure 2 shows the electrical activity simultaneously recorded from the Pacinian corpuscle and its sensory neurone when increasing pressure was applied to a fingertip.

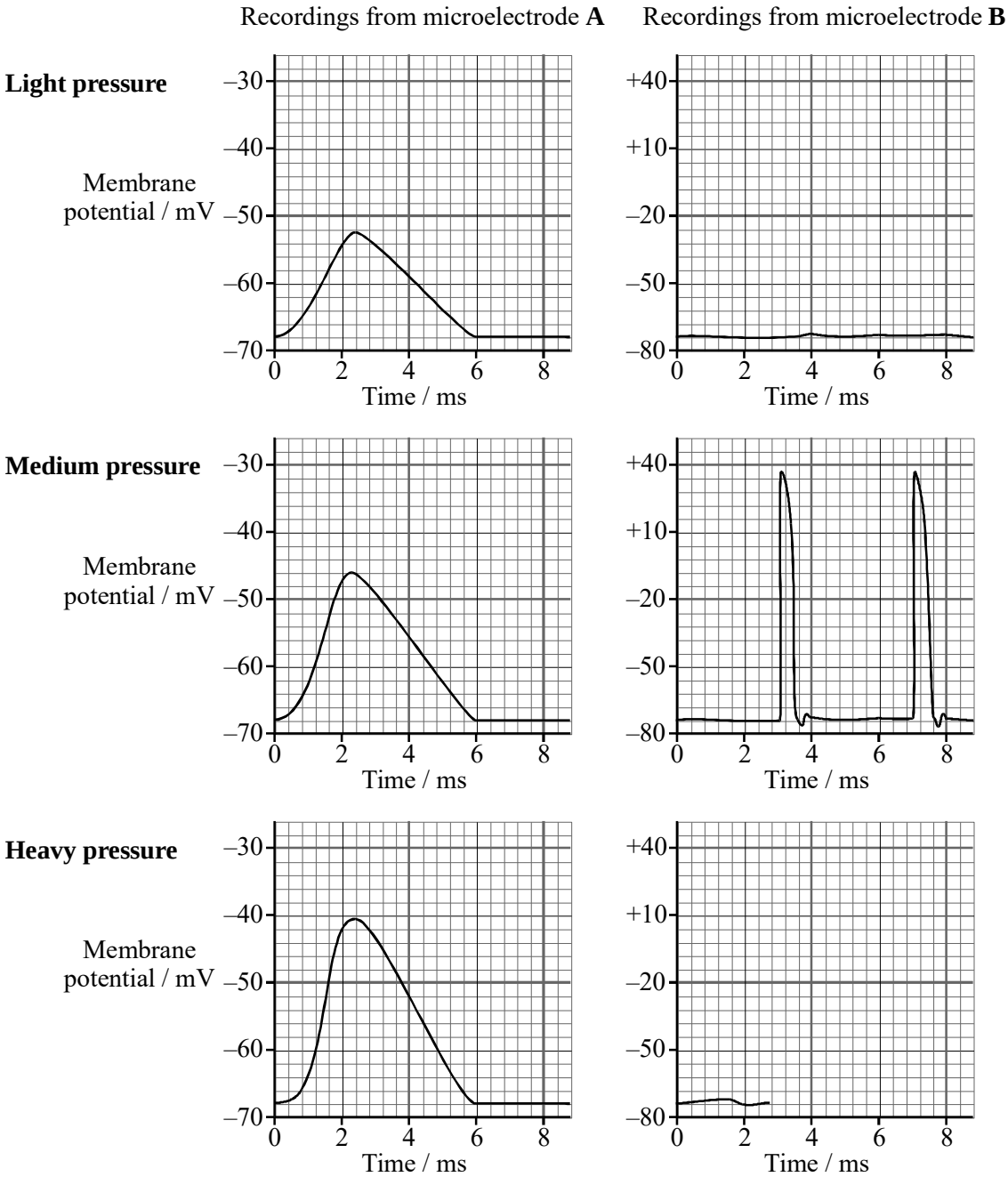

Figure 2

(a) Explain how pressure on the Pacinian corpuscle produces the changes in membrane potential recorded by microelectrode **A**.

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(2)

(b) (i) Draw an arrow on **Figure 1** to show the direction of net movement of potassium ions during repolarisation of the sensory neurone. Label this arrow with the letter **K**.

(1)

(ii) Complete **Figure 2** to show the expected electrical activity recorded by microelectrode **B** when high pressure was applied to the fingertip.

(1)

(c) (i) What is the delay between the maximum depolarisation recorded by microelectrode **A** and the first depolarisation recorded by microelectrode **B** when medium pressure was applied to the fingertip?

Answer ..... ms

(1)

(ii) The distance between microelectrodes **A** and **B** is 8 cm. Use this information together with your answer to (c) (i) to calculate the speed of conductance of an impulse along the sensory neurone, in metres per second. Show your working.

Answer ..... ms^{-1}

(1)

(d) Most of the sensory neurone in **Figure 1** is covered by a myelin sheath. This prevents the movement of ions across the axon membrane except at the small gaps in the sheath, called the nodes of Ranvier. Multiple sclerosis is a disease in which the myelin sheaths surrounding the neurones are destroyed so the neurones become de-myelinated.

(i) Explain how de-myelination of neurones produces slow responses to stimuli in people with multiple sclerosis.

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(2)

(ii) The rate of ATP consumption of a de-myelinated neurone is greater than that of a myelinated neurone when conducting impulses at the same frequency. Explain why.

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(2)

(e) Hydra is a small animal which lives in water. It traps food particles by random movement of its tentacles. The rate of tentacle movement is usually slow but becomes faster as more tentacles touch food particles.

(i) Name the type of behaviour described above.

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(1)

(ii) Give a reason for your answer.

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(1)

(Total 12 marks)

8. All living organisms exist in changing external environments and many are able to control their internal environments.

(a) Explain how the body of a mammal may respond to a rise in the environmental temperature.

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(8)

(b) Describe the important differences between the nervous and hormonal co–ordination systems found in a mammal.

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(4)
(Total 12 marks)

9. (a) Explain what is meant by a reflex action.

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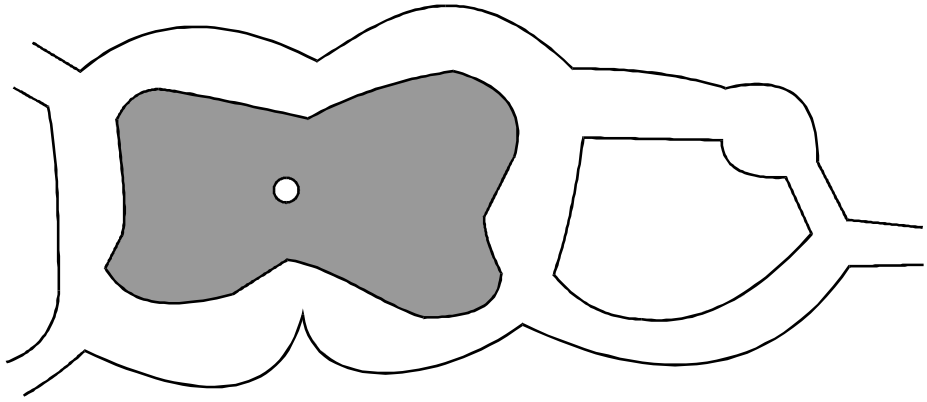
(3)

(b) On the diagram draw a simple spinal reflex arc involving three neurones. Label each neurone.



(3)
(Total 6 marks)

10. (a) The presence of food in the mouth stimulates glands to secrete saliva into the mouth. Non-food items, such as a piece of rubber, have the same effect.

Describe how the component parts of the nervous system bring about this reflex action.

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(4)

(b) When food enters the stomach it stimulates the production of a hormone from glands in the stomach wall. This hormone causes the release of digestive juices by the stomach.

Give **three** ways in which hormonal coordination differs from nervous coordination.

1 .....

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2 .....

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3 .....

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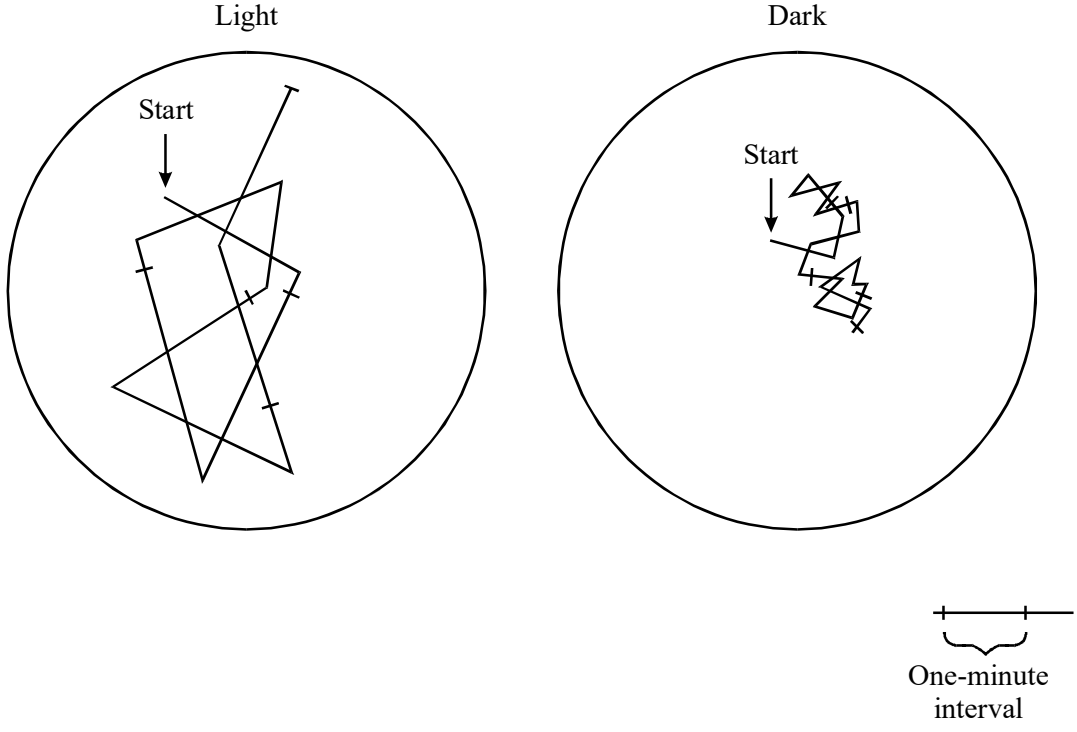
(3)
(Total 7 marks)

11. Woodlice are small animals that live under **stones** in damp conditions. In a study of behaviour, a woodlouse was put into a Petri dish in the **light** for five minutes. The same woodlouse was then put into another Petri dish in the dark for a further five minutes. The drawings show the paths of the same woodiouse plotted for five minutes in each condition.



(a) Describe **two** ways in which the behaviour of the woodlouse in the light differed from its behaviour in the dark.

1 .....

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2 .....

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(2)

(b) (i) Which type of innate behaviour is shown by the woodiouse in this investigation?

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(1)

(ii) Suggest the importance of this behaviour for survival in woodlice.

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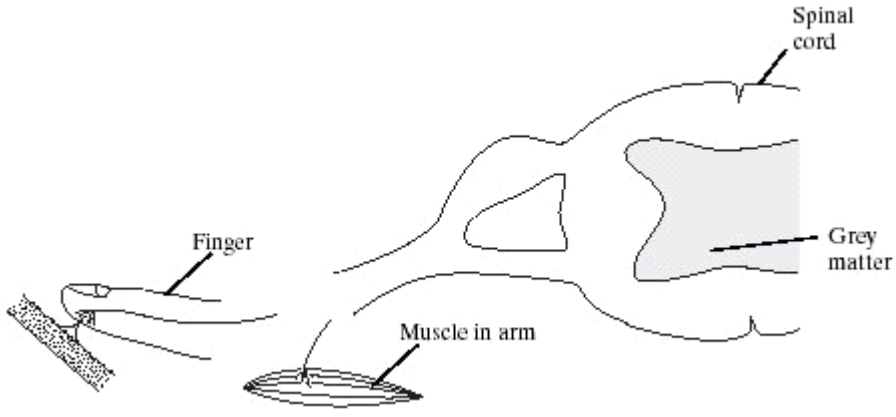
(2)
(Total 5 marks)

12. A gardener accidentally pricks a finger on a thorn. She quickly pulls the finger away. This reaction results from a simple reflex arc involving three neurones.

(a) The diagram shows part of the pathway involved in this reaction.



(i) Complete the diagram to show the rest of the simple reflex arc.

(1)

On your diagram

(ii) name and label the **three** neurones;

(iii) label the effector.

(2)

(b) As well as pulling the finger away, the gardener also feels pain caused by the thorn. Explain how she becomes aware of the pain.

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(3)

(Total 6 marks)