**Q1.**

Termites are insects. Some species live in colonies in the soil. Although most termites are wingless, winged termites are sometimes produced. The winged termites fly from the soil, mate and start new colonies.

A scientist studied the behaviour of winged termites. He divided these termites into three groups.

•        Group **A** had their eyes covered.

•        Group **B** had their antennae removed.

•        Group **C** was the control group.

He put individual winged termites on a sloping board that was illuminated from one side. The diagram shows the direction of movement of a typical termite from each of the three groups.

Map

Description automatically generated

(a)     (i)      What type of behaviour was shown by the termite from group **B**?

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**(1)**

(ii)     Give the evidence for your answer.

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**(1)**

(b)     Explain what the results from group **A** suggest about the factors controlling the behaviour of winged termites.

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**(3)**

(c)     Suggest **one** advantage to the termites from group **C** of the behaviour shown in the investigation.

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**(2)**

**(Total 7 marks)**

**Q2.**

**Figure 1** shows an investigation into growth factors in plants.

**Figure 1**

**A picture containing text, ax, tool

Description automatically generated**

(a)  Use your knowledge of indoleacetic acid (IAA) to explain the growth curvature shown in **Figure 1**.

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**(3)**

A bioassay is a method to determine the concentration of a substance by its effect on living tissues.

**Figure 2** shows the practical procedure used in a growth curvature bioassay to determine the concentration of IAA in shoot tips.

**Figure 2**

**Diagram

Description automatically generated**

**Figure 3** shows the calibration curve for this growth curvature bioassay.

**Figure 3**

**Chart, line chart

Description automatically generated**

(b)  Using the procedure in **Figure 2** and the calibration curve in **Figure 3**, describe how you could compare the IAA concentration in shoot tips from two different plant species.

In your answer you should refer to all the variables that should be controlled to produce a valid comparison.

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**(5)**

A scientist investigated the effect of a directional light stimulus on the distribution of IAA in shoot tips. The scientist set up three experiments as shown in **Figure 4**. All variables were controlled apart from exposure to light.

**Figure 4**

**Diagram

Description automatically generated**

She then used the growth curvature bioassay to compare the IAA concentrations in the agar blocks from:

•   experiment **1**

•   experiment **2**

•   experiment **3** section **A**

•   experiment **3** section **B**.

The table below shows the scientist’s results.

|  |  |
| --- | --- |
| **Experiment** | **Degree of curvature in Bioassay / degrees** |
| **1** | 17.69 |
| **2** | 17.61 |
| **3A** | 11.22 |
| **3B** | 6.50 |

(c)  State **two** conclusions about IAA that you can make from the results shown in the table above.

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2  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 10 marks)**

**Q3.**

A student investigated the effects of indoleacetic acid (IAA) on the growth of oat seedlings (young plants).

The student:

•   removed the shoot tip from each seedling and cut out a 10 mm length of shoot

•   placed 10 lengths of shoot into each of 5 Petri dishes

•   added to each Petri dish an identical volume of 5% glucose solution

•   added to each Petri dish 40 cm3 of a different concentration of IAA solution

•   left the Petri dishes at 20 °C in the dark with their lids on for 5 days

•   removed the shoots after 5 days and measured them

•   determined the mean change in length of shoot at each concentration of IAA.

**Table 1** shows her results.

**Table 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **IAA concentration added to Petri dish / parts per million** | 10−5 | 10−3 | 10−1 | 1 | 10 |
| **Mean change in length of shoot / mm** | 0.0 | 0.1 | 1.3 | 2.4 | 3.1 |

(a)  Explain why the student removed the shoot tip from each seedling.

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**(2)**

(b)  Explain why the student added glucose solution to each Petri dish.

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**(2)**

(c)  Explain why the lids were kept on the Petri dishes.

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(d)  Describe and explain the results shown in **Table 1** above and suggest how the results might have differed if lengths of **root** had been used.

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**(3)**

(e)  The student produced the different concentrations of IAA using a stock 1 g dm−3 solution of IAA (1 g dm−3 = 1 part per thousand) and distilled water.

Complete **Table 2** with the volumes of stock IAA solution and distilled water required to produce 40 cm3 of 10 ppm (parts per million) IAA solution.

**Table 2**

|  |  |  |
| --- | --- | --- |
| **Concentration of IAA solution / parts per million** | **Volume of stock IAA solution / cm3** | **Volume of distilled water / cm3** |
| 10 |  |  |

**(1)**

**(Total 10 marks)**

**Q4.**

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.

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

Diagram

Description automatically generated

(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)**

**(Total 3 marks)**

**Q5.**

(a)     Describe how a Pacinian corpuscle produces a generator potential when stimulated.

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**(3)**

Doctors investigated the relationship between heart rate and arterial blood pressure. They recruited healthy volunteers. For each volunteer, they recorded their normal arterial blood pressure at rest. With each volunteer, they then carried out the following experiments.

|  |  |
| --- | --- |
| **Experiment 1 Experiment 2  Experiment 3** | They recorded heart rate at different blood pressures. They repeated **experiment 1** after injecting a drug that inhibited the parasympathetic nervous system. They repeated **experiment 1** after injecting a drug that inhibited the sympathetic nervous system. |

The graph shows the results for one volunteer.

Chart

Description automatically generated

(b)     Calculate the ratio of heart rate in **experiment 2** to heart rate in **experiment 3** at an arterial blood pressure of 10 kPa.  
Show your working.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     What do these data suggest about the control of heart rate by the parasympathetic and sympathetic nervous systems in response to changes in arterial blood pressure?

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**(3)**

**(Total 8 marks)**

**Q6.**

When a person looks directly at an object, its image is focused on the fovea.

(a)     When the image is focused on the fovea, the person sees the object in colour.  
Explain why.

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(*Extra space*) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(b)     Vision using the fovea has high visual acuity but low sensitivity to light compared with vision using other parts of the retina.

(i)      Explain why vision using the fovea has high visual acuity.

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**(1)**

(ii)     Explain why vision using other parts of the retina has high sensitivity to light.

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**(3)**

**(Total 7 marks)**

**Q7.**

The retinas in the eyes of humans and birds have cone cells that absorb light of different wavelengths.

A scientist recorded the absorption of light of different wavelengths by different types of human cone cells. Her results are shown in **Figure 1**. Each curve shows the absorption of light by one type of cone cell.

**Figure 1**

**Chart

Description automatically generated**

She also recorded the absorption of light of different wavelengths by different types of bird cone cells. These results are shown in **Figure 2**. Each curve shows the absorption of light by one type of cone cell.

**Figure 2**

**Chart

Description automatically generated**

Human colour vision has been explained by the trichromatic theory, meaning that it is based on three colours.

(a)     Explain how the evidence from **Figure 1** supports this theory.

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**(2)**

(b)     Humans see more than three colours.

Use evidence from **Figure 1** to suggest how.

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**(1)**

(c)     Compare and contrast the wavelengths of maximum absorption by the cone cells in bird retinas and human retinas.

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**(3)**

(d)     Cone cells give higher visual acuity than rod cells.

Explain how.

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**(2)**

(e)     The cone density is highest on the fovea in the centre of the retina. In a human fovea there are 150 000 cones per mm2. The diameter of a human fovea is 1.4 mm.

Calculate the number of cones on the human fovea.

The formula for calculating the area of a circle is *πr*2.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 10 marks)**

**Q8.**

The diagram shows part of the retina in a human eye.

Diagram

Description automatically generated

(a)     Explain each of the following observations.

(i)      When light falls on cells **1** and **2**, only one spot of light is seen. But, when light falls on cells **2** and **3**, two spots of light are seen.

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**(1)**

(ii)     When one unit of light energy falls on cell **3**, no light is seen. But, when one unit of light energy falls on cell **3**, one unit falls on cell **4** and one unit falls on cell **5**, light is seen.

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**(3)**

(b)     Cells of the same type as cells **6** and **7** are found in large numbers at the fovea. This results in colour vision with high visual acuity.

Explain what causes vision using the fovea.

(i)      to be in colour;

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**(1)**

(ii)     to have high visual acuity.

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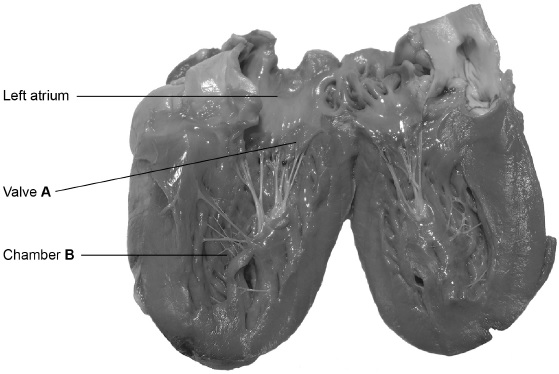
**(1)**

**(Total 6 marks)**

**Q9.**

**Figure 1** shows a photograph of a dissected heart.

**Figure 1**

****

(a)  Name valve **A** and chamber **B**.

Valve **A** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Chamber **B** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)  Give **two** safety precautions that should be followed when dissecting a heart.

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**(1)**

(c)  Explain how valve **A** in **Figure 1** maintains a unidirectional flow of blood.

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**(2)**

A research scientist investigated the effect of caffeine on heart rate in human volunteers.

The scientist divided volunteers into three groups. Each group was given the same volume of fluid.

•   Each member of Group **I** was given a sports drink containing caffeine and sugar.

•   Each member of Group **J** was given a sports drink containing caffeine and no sugar.

•   Each member of Group **K** was given water.

The scientist recorded the volunteers’ heart rate before the drink was given and for 120 minutes after the drink was given.

Her results can be seen in **Figure 2**.

**Figure 2**

**Chart

Description automatically generated**

(d)  Caffeine affects the autonomic nervous system.

Suggest how caffeine could account for the results of Group **I** in **Figure 2** at 60 minutes.

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**(2)**

(e)  Before taking the drink, the mean heart rate of Group **J** was 68 beats per minute.

Fifteen minutes after taking the drink, the mean volume of blood leaving the hearts of Group **J** was 4700 cm3 per minute.

Calculate the mean volume of blood leaving the heart at each beat fifteen minutes after taking the drink.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cm3

**(1)**

(f)   The increase seen in Group **I** could be due to the combination of caffeine and sugar.

Suggest **one** drink to be given to an **additional** group that should be investigated to find out if this is true.

Give a reason for your answer.

Group to be given \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

**(Total 9 marks)**

**Q10.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Body position** | **Pulse rate / beats per minute** | | | |
| Reading 1 | Reading 2 | Reading 3 | Mean |
| Sitting | 80 | 76 | 76 | 77 |
| Standing | 84 | 88 | 92 | 88 |
| Lying down | 68 | 72 | 68 | 69 |

(a)     Using the results in the table above, calculate the percentage decrease in mean pulse rate when lying down compared with when standing.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ %

**(2)**

(b)     When the heart beats, both ventricles contract at the same time.

Explain how this is coordinated in the heart after initiation of the heartbeat by the SAN.

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**(2)**

**(Total 4 marks)**

**Q11.**

(a)    Describe how a heartbeat is initiated and coordinated.

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**(5)**

(b)     Explain how the heart muscle and the heart valves maintain a one-way flow of blood from the left atrium to the aorta.

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**(5)**

**(Total 10 marks)**