**Q1.**(a)     Describe the induced-fit model of enzyme action.

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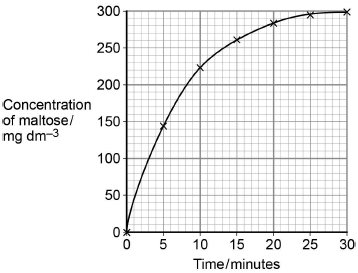
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**(2)**

(b)     A scientist investigated the hydrolysis of starch.He added amylase to a suspension of starch and measured the concentration of maltose in the reaction mixture at regular intervals.

His results are shown in the graph below.



Determine the rate of the reaction **at** 10 minutes.

Show how you obtained your answer.

Rate of reaction .............................................. mg dm−3 min−1

**(2)**

c)     Explain the results shown in the graph.

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**(2)**

(d)     A quantitative Benedict’s test produces a colour whose intensity depends on the concentration of reducing sugar in a solution. A colorimeter can be used to measure the intensity of this colour.

The scientist used quantitative Benedict’s tests to produce a calibration curve of colorimeter reading against concentration of maltose.

Describe how the scientist would have produced the calibration curve and used it to obtain the results in the graph.

Do **not** include details of how to perform a Benedict’s test in your answer.

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**(3)**

**(Total 9 marks)**

**Q2.**A student investigated the distribution of stomata on leaves from two species of plant. She removed small pieces from the lower surface of the leaves of each plant species. She mounted these pieces on separate microscope slides. She then counted the number of stomata in several parts of the epidermis on each piece of leaf tissue using an optical microscope.

(a)     Suggest appropriate units the student should use to compare the distribution of stomata on leaves.

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**(1)**

(b)     The pieces of leaf tissue examined were very thin.

Explain why this was important.

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**(2)**

(c)     Give **two** reasons why it was important that the student counted the number of stomata in several parts of each piece of leaf tissue.

1 ..........................................................................................................................

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2 ..........................................................................................................................

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**(2)**

(d)     One of the two plant species used by the student in this investigation was a xerophyte.

Other than the distribution of stomata, suggest and explain **two** xerophytic features the leaves of this plant might have.

1 ..........................................................................................................................

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2 ..........................................................................................................................

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**(2)**

(e)     The student then compared the rate of transpiration (evaporation of water) from the two species of plant. She did this by measuring the rate of water uptake by each plant species.

Suggest **two** reasons why the rate of water uptake by a plant might not be the same as the rate of transpiration.

1 ..........................................................................................................................

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2 ..........................................................................................................................

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**(2)**

**(Total 9 marks)**

**Q3.**          (a)     Describe the part played by the inner membrane of a mitochondrion in producing ATP.

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**(3)**

(b)     A scientist investigated ATP production in a preparation of isolated mitochondria. He suspended the mitochondria in an isotonic solution and added a suitable respiratory substrate together with ADP and phosphate. He bubbled oxygen through the preparation.

(i)      Why was the solution in which the mitochondria were suspended isotonic?

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**(1)**

(ii)     Explain why the scientist did **not** use glucose as the respiratory substrate.

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**(2)**

(iii)     Explain why the oxygen concentration would change during this investigation.

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**(1)**

**(Total 7 marks)**

**Q4.**Lettuce is classified in the same family as dandelions. Dandelions commonly grow on roadside verges and may accidentally be sprayed with salt when salt is added to the road in winter.

Describe how you could use a transect to investigate whether the distribution of dandelions changed with increased distance from the road.

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**(Total 4 marks)**

**Q5.**          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.

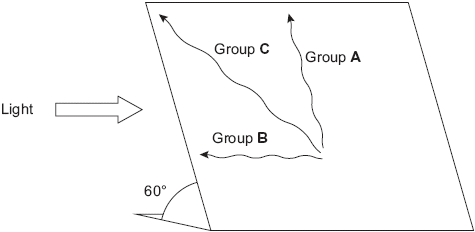
A scientist studied the behaviour of winged termites. He divided these termites into three groups.

•        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.



(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)**

**Q6.**          A Sri Lankan scientist investigated the effect of human disturbance on the organisms living on a rocky seashore. He chose three areas for the study. These areas had different amounts of human disturbance.

The scientist measured human disturbance by walking from one end of the beach to the other. He recorded the number of people he encountered. **Figure 1** shows his results.

**Figure 1**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Site **R** | Site **G** | Site **U** |
| Mean number of people encountered per hour (± standard deviation) | 2.2 (± 2.1) | 17.6 (± 9.6) | 34.6 (± 11.6) |
|  |  |  |  |

(a)     (i)      What conclusions can you draw about the number of people visiting Site **R** compared with the number of people visiting the other two sites? Give evidence from **Figure 1** to support your answer.

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**(2)**

(ii)     The scientist reported that the difference between the number of people visiting Site **R** and the number visiting the other two sites differed significantly (p < 0.05).

Use the words probability and chance to explain the meaning of *differed significantly (p < 0.05).*

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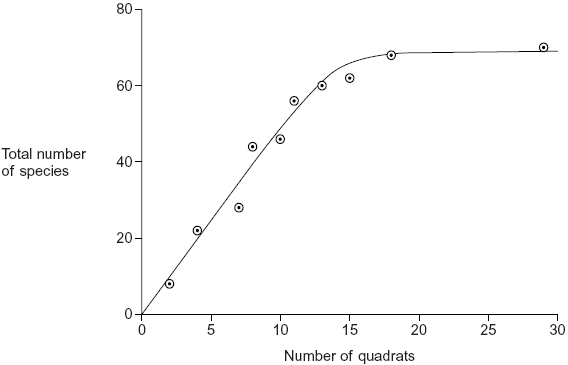
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**(2)**

(b)     The scientist used quadrats to find the number of species at each of the three sites. He carried out a preliminary investigation and recorded the total number of species in an increasing number of quadrats. **Figure 2** shows the results.

**Figure 2**

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(i)      Use **Figure 2** to explain why 10 would **not** be an appropriate number of quadrats to use.

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**(1)**

(ii)     Use **Figure 2** to explain why 25 would **not** be an appropriate number of quadrats to use.

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**(1)**

          The scientist measured the dry biomass of seaweeds at each of sites **R**, **G** and **U**. He collected all the organisms of a particular species in a quadrat and incubated them in an oven at a temperature of 80 °C.

(c)     The scientist incubated the seaweeds at 80 °C. Suggest why incubating them at a higher temperature would **not** produce valid results.

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**(1)**

As well as measuring the dry biomass of the seaweeds, the scientist measured the dry mass of the animals present. He also measured the abundance of each species. **Figure 3** shows the data he collected.

**Figure 3**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Site **R** | Site **G** | Site **U** |
| Mean number of people per hour | 2.2 | 17.6 | 34.6 |
| Mean number of species of seaweed per quadrat | 4.2 | 2.1 | 1.3 |
| Ratio of dry biomass of animals to dry biomass of seaweeds | 0.15 | 0.06 | 0.03 |
| Ratio of dry biomass of animals to abundance of animals | 0.20 | 0.10 | 0.09 |
| Ratio of dry biomass of seaweeds to abundance of seaweeds | 0.79 | 1.57 | 3.24 |

(d)     The ratio of the dry biomass of animals to the dry biomass of seaweeds is always a lot less than one. Explain why.

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**(2)**

(e)     (i)      Conservation officers were working on the beaches used in this investigation. They noticed that there were fewer larger seaweeds on beaches used by a large number of people than on beaches visited by only a few people. Explain how the data in **Figure 3** support this.

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**(2)**

(ii)     What conclusions can you draw from the data in **Figure 3** about the effect of human disturbance on the animals living on the seashore? Explain your answer.

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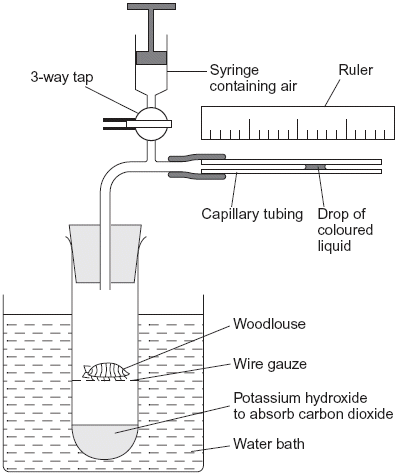
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**(4)**

**(Total 15 marks)**

**Q7.**          (a)     A student measured the rate of aerobic respiration of a woodlouse using the apparatus shown in the diagram.



(i)      The student closed the tap. After thirty minutes the drop of coloured liquid had moved to the left. Explain why the drop of coloured liquid moved to the left.

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**(3)**

(ii)     What measurements should the student have taken to calculate the rate of aerobic respiration in mm3 of oxygen g–1 h–1?

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**(3)**

(b)     DNP inhibits respiration by preventing a proton gradient being maintained across membranes. When DNP was added to isolated mitochondria the following changes were observed

•        less ATP was produced

•        more heat was produced

•        the uptake of oxygen remained constant.

Explain how DNP caused these changes.

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**(3)**

**(Total 9 marks)**

**Q8.**          (a)     Blue tits are small birds that live in woods. An ecologist estimated the size of the blue tit population visiting gardens near a wood in November.

•        She trapped 28 blue tits. She marked all of these birds with small metal rings on their legs.

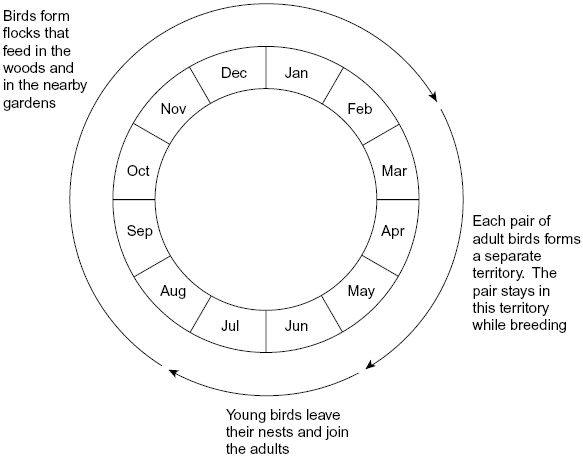
•        Two weeks later, she trapped another sample of blue tits. Of these birds, 18 were marked and 20 were not marked.

Use the data to estimate the size of the blue tit population. Show your working.

Size of population ....................................

**(2)**

(b)     The diagram shows some features of blue tit behaviour at different times of the year.



(i)      Using mark-release-recapture to estimate the size of a blue tit population in June would **not** give reliable results. Explain why.

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**(2)**

(ii)     Using mark-release-recapture to estimate the size of a blue tit population in March would **not** give reliable results. Explain why.

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**(2)**

(c)     Whales spend most of their time deep in the sea but they come to the surface to breathe. When they are at the surface, scientists obtain small samples of their skin. The scientists find the base sequence in some of the DNA from these samples. The base sequence is different in each whale.

You could use the information about the base sequence to estimate the size of the whale population by using mark-release-recapture. Explain why.

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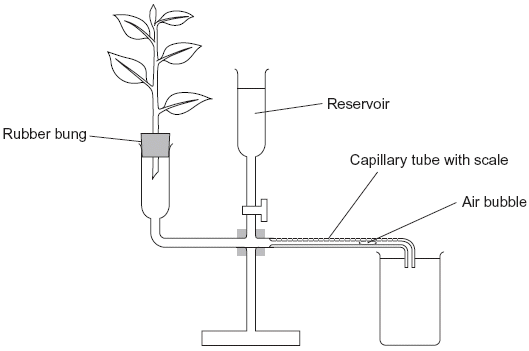
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**(2)**

**(Total 8 marks)**

**Q9.**A student investigated the rate of transpiration from a leafy shoot. She used a potometer to measure the rate of water uptake by the shoot. The diagram shows the potometer used by the student.



(a)     Give **one** environmental factor that the student should have kept constant during this investigation.

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**(1)**

(b)     The student cut the shoot and put it into the potometer under water. Explain why.

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**(1)**

(c)     The student wanted to calculate the rate of water uptake by the shoot in cm3 per minute. What measurements did she need to make?

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**(2)**

(d)     The student assumed that water uptake was equivalent to the rate of transpiration.

Give **two** reasons why this might **not** be a valid assumption.

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2 ...................................................................................................................

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**(2)**

(e)     The student measured the rate of water uptake three times.

(i)      Suggest how the reservoir allows repeat measurements to be made.

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**(1)**

(ii)     Suggest why she made repeat measurements.

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**(1)**

**(Total 8 marks)**

**Q10.**          Read the following passage.

Some foods contain substances called flavenoids. Flavenoids lower blood  
cholesterol concentration and reduce the risk of developing coronary  
heart disease.

Some types of dark chocolate have a high concentration of flavenoids. One

5        group of scientists investigated the effect of eating dark chocolate on the risk

of developing coronary heart disease.

The scientists randomly divided healthy volunteers into two groups. Every day  
one group was given dark chocolate containing flavenoids to eat. The other  
group acted as a control.

10      The scientists measured the diameter of the lumen of the main artery in the

arms of the volunteers every week. At the end of a month, the diameter of  
the lumen of the main artery in the arm of the volunteers who had eaten  
dark chocolate containing flavenoids had increased.

Use information from the passage and your own knowledge to answer the questions.

(a)     (i)      The scientists used healthy volunteers in this investigation (line 7). Why was it important that the volunteers were healthy?

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**(1)**

(ii)     The scientists randomly divided the volunteers into two groups (line 7). Explain why they divided them randomly.

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**(1)**

(b)     (i)      Describe how the control group should have been treated.

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**(2)**

(ii)     Why was it important to have a control group in this investigation?

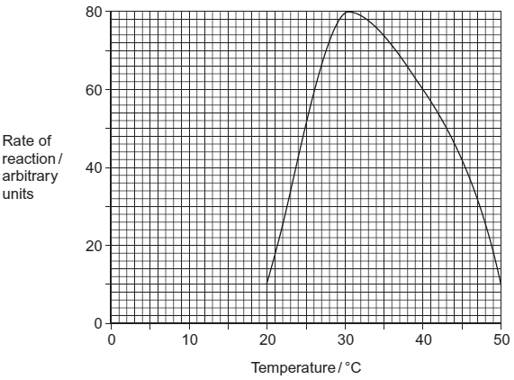
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**(1)**

**(Total 5 marks)**

**Q11.**          A protease is an enzyme that digests protein. The graph shows how the activity of a protease varies with temperature.



(a)     (i)      Describe what the graph shows about the effect of temperature on the rate of reaction.

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**(1)**

(ii)     Explain the shape of the curve between 30 °C and 50 °C.

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**(3)**

(b)Students investigated the effect of pH on the activity of the protease.

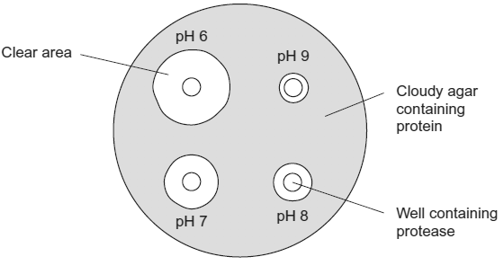
•        The students used agar plates containing protein. The protein made the agar cloudy.

•They made four wells of equal size in the agar of each plate.

•They added a drop of protease solution to each of the wells. The protease solution in each well was at a different pH.

•The students incubated the agar plates for 4 hours at a constant temperature.

The diagram shows the agar plates after they were incubated and the pH of the protease solution in each well.



(i)      How should the students make sure that the pH of the protease solution did **not** change?

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**(1)**

(ii)     Use the graph to suggest a suitable temperature for incubating the agar plates.

Explain your answer.

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**(1)**

(iii)     Use the diagram to describe the effect of pH on the activity of this protease.

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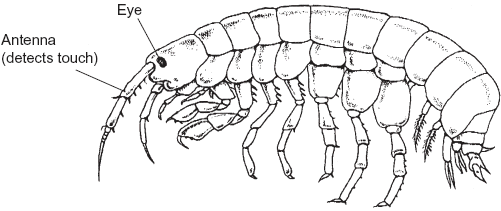
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**(1)**

**(Total 7 marks)**

**Q12.**          **Figure 1** shows a fresh-water shrimp.

**Figure 1**

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Biologists collected shrimps from a stream inside a cave and from the same stream when it was in the open.

They measured the maximum diameter of each shrimp’s eye. They also measured the length of its antenna. From these measurements they calculated the mean values for each site. **Figure 2** shows their results.

**Figure 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Shrimps from the stream | |
|  |  | Inside the cave | In the open |
|  | Mean diameter of eye /mm | 0.09 | 0.24 |
|  | Mean length of antenna /mm | 8.46 | 5.81 |

(a)     The biologists measured the maximum diameter of each shrimp’s eye.

Explain why they measured the **maximum** diameter.

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**(1)**

(b)     A scientist working many years earlier suggested that animals which live in caves had similar adaptations. These adaptations included

•        smaller eyes

•        greater use of sense organs such as those involved in detecting touch.

(i)      Do the data in **Figure 2** support this scientist’s suggestion? Explain your answer.

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**(2)**

(ii)     The data in **Figure 2** are mean values. Explain how standard deviations of these cmean values would help you to interpret the data in **Figure 2**.

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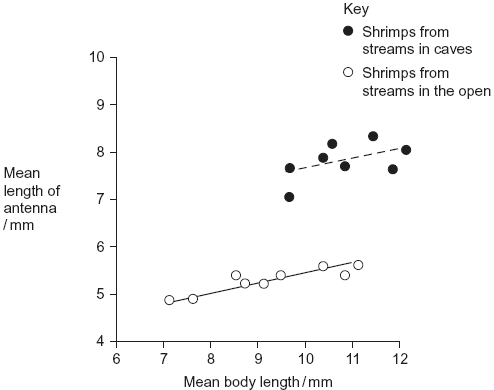
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**(2)**

(c)     The biologists investigated shrimps living in other streams. They measured the length of the antennae of these shrimps. They also measured their body length. **Figure 3** shows the mean antenna length plotted against mean body length for each site.

**Figure 3**

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(i)      What does the information in the graph suggest about the body lengths of shrimps living in caves and living in the open?

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**(2)**

(ii)     Do the data in the graph support the conclusion that shrimps with longer bodies have longer antennae? Give the reason for your answer.

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**(1)**

Other biologists investigated the genetic diversity of these shrimps. **Figure 4** shows some of the data they collected.

**Figure 4**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Gene** | **Allele** | **Percentage of shrimps with this allele in steam** | |
|  | **Inside a cave** | **In the open** |
|  | PGI | **A** | 0.9 | 2.5 |
|  | **B** | 0.0 | 3.3 |
|  | **C** | 98.2 | 66.4 |
|  | **D** | 0.9 | 6.6 |
|  | **E** | 0.0 | 21.3 |
|  |  | | | |
|  | ACO2 | **J** | 0.0 | 5.6 |
|  | **K** | 0.0 | 76.7 |
|  | **L** | 100.0 | 17.8 |

(d)     The biologists concluded that the shrimps in the open had a higher genetic diversity than those in the cave. Explain how the data in **Figure 4** support this conclusion.

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**(1)**

(e)     The percentage of shrimps with allele **L** in the cave is different from the percentage of shrimps with allele **L** in the open. Use your knowledge of the founder effect to suggest a reason for this difference.

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**(3)**

(f)      The biologists who studied these shrimps wanted to know if the shrimps living in the cave were the same species as those living in the open. They used breeding experiments to investigate this.

(i)      Describe how the biologists should carry out these breeding experiments.

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(ii)     The results of breeding experiments would help the biologists to decide whether the shrimps were the same species. Explain how.

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**(3)**

**(Total 15 marks)**

**Q13.**          A student investigated the effect of putting cylinders cut from a potato into sodium chloride solutions of different concentration. He cut cylinders from a potato and weighed each cylinder. He then placed each cylinder in a test tube. Each test tube contained a different concentration of sodium chloride solution. The tubes were left overnight. He then removed the cylinders from the solutions and reweighed them.

(a)     Before reweighing, the student blotted dry the outside of each cylinder. Explain why.

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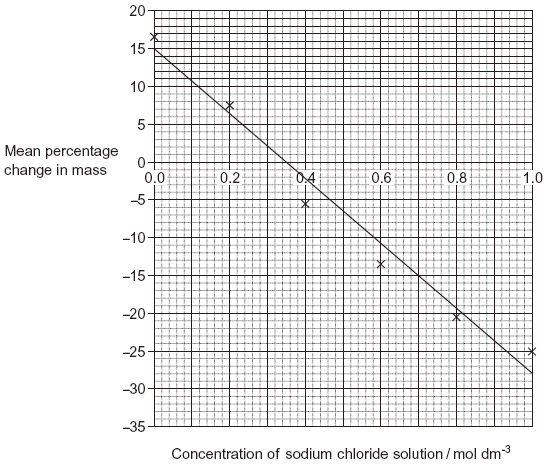
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**(2)**

The student repeated the experiment several times at each concentration of sodium chloride solution. His results are shown in the graph.



(b)     The student made up all the sodium chloride solutions using a 1.0 mol dm–3 sodium chloride solution and distilled water.

Complete the table to show how he made 20 cm3 of a 0.2 mol dm–3 sodium chloride solution.

|  |  |  |
| --- | --- | --- |
|  | **Volume of 1.0 mol dm–3 sodium chloride solution** | **Volume of distilled water** |
|  |  |  |

**(1)**

(c)     The student calculated the *percentage* change in mass rather than the change in mass. Explain the advantage of this.

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**(2)**

(d)     The student carried out several repeats at each concentration of sodium chloride solution. Explain why the repeats were important.

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**(2)**

(e)     Use the graph to find the concentration of sodium chloride solution that has the same water potential as the potato cylinders.

.............................. mol dm–3

**(1)**

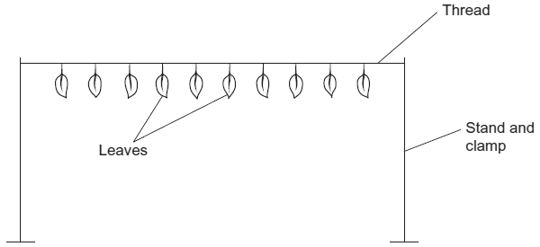
**(Total 8 marks)**

**Q14.**          A student investigated the rate of transpiration from privet leaves.

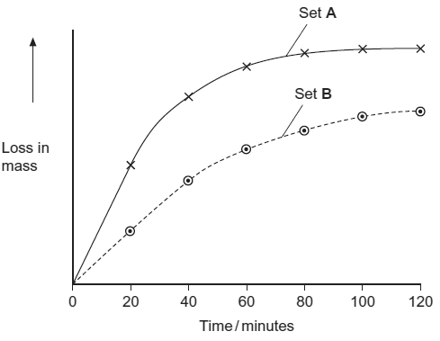
•        She obtained two sets of ten privet leaves.

•        She left the ten leaves in set **A** untreated. She covered the upper surfaces of the ten leaves in set **B** with grease.

•        She weighed each set of leaves and then tied all the leaves in each set to a separate length of thread. This is shown in the diagram.



•        She then weighed each set of leaves every 20 minutes over a period of 2 hours and plotted a graph of her results.



(a)Give **two** environmental conditions that the student should have kept constant during this investigation.

1 ...................................................................................................................

2 ...................................................................................................................

**(2)**

(b)The student measured the water loss in milligrams. Explain the advantage of using ten leaves when taking measurements in milligrams.

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**(1)**

(c)Explain the change in mass of untreated leaves in set **A** shown in the graph.

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**(3)**

(d)The results that the student obtained for the leaves in set **B** were different from those for set **A**. Suggest an explanation for this difference.

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**(2)**

**(Total 8 marks)**

**Q15.**          (a)     Give **two** ways in which active transport is different from facilitated diffusion.

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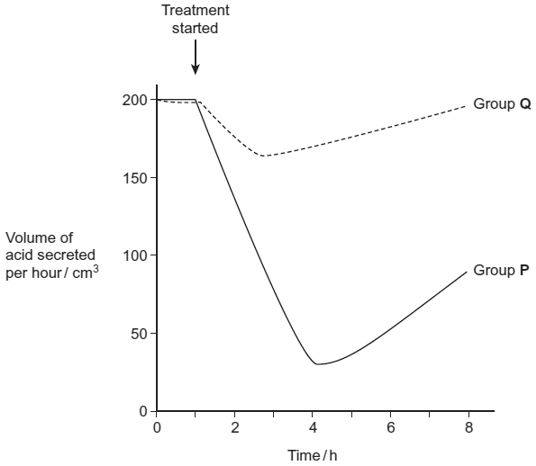
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**(2)**

Scientists investigated the effect of a drug called a proton pump inhibitor. The drug is given as a tablet to people who produce too much acid in their stomach. It binds to a carrier protein in the surface membrane of cells lining the stomach. This carrier protein usually moves hydrogen ions into the stomach by active transport.

The scientists used two groups of people in their investigation. All the people produced too much acid in their stomach. People in group **P** were given the drug. Group **Q** was the control group.

The graph shows the results.



(b)(i)      The scientists used a control group in this trial. Explain why.

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**(1)**

(ii)     Suggest how the control group would have been treated.

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**(2)**

(c)Describe the effect of taking the drug on acid secretion.

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**(1)**

**(Total 6 marks)**

**Q16.**In some countries, pigs are reared in intensive units in which the temperature is controlled. Agricultural  
scientists investigated the effect of temperature on pig growth and on the efficiency with which the pigs  
converted food to biomass.

(a)     (i)      In the investigation, the scientists used pigs of the same breed, with similar genotypes.  
Explain why.

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**(2)**

(ii)     The pigs were allowed to eat as much food as they wanted.  
How could this have decreased the reliability of any conclusions drawn from the  
investigation?

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**(2)**

The table shows the results of this investigation.

|  |  |  |
| --- | --- | --- |
| **Temperature / °C** | **Mean growth rate / kg per day** | **Efficiency of conversion of food to biomass /%** |
| 0 | 0.54 | 19 |
| 10 | 0.80 | 42 |
| 20 | 0.85 | 48 |
| 30 | 0.45 | 37 |
| 35 | 0.31 | 37 |

(b)     (i)      Describe the effect of temperature on mean growth rate.

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**(1)**

(ii)     A student concluded from these data that the mean growth rate of the pigs was fastest at 20 °C.  
Do you agree with this conclusion? Explain your answer.

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**(2)**

(c)     (i)      Pigs can survive at temperatures above 35 °C. Use the data to suggest why scientists did **not**carry out any investigations at temperatures higher than 35 °C.

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**(2)**

(ii)     The efficiency of conversion of food to biomass is lower at 0 °C than it is at 20 °C.  
Suggest an explanation for the lower efficiency.

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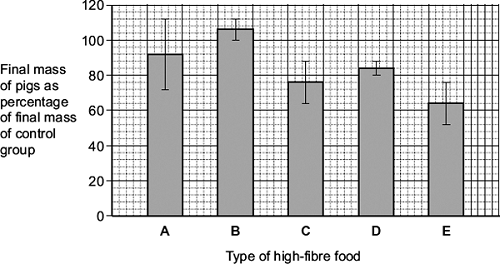
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**(2)**

(d)     Pigs require a mixture of fibre and protein in their food. The greater the ratio of fibre to protein, the less  
the food costs.

Scientists took five large groups of pigs. They fed each group a different high-fibre food. Each of the foods contained fibre from different plant species, but they all had the same energy content. The scientists fed a control group of pigs a low-fibre food with the same energy content. After 10 days, the scientists compared  
the masses of the pigs fed on high-fibre food to those fed on low-fibre food.

The graph shows the results of the investigation. The bars represent ±2 standard errors of the mean.



A farmer saw these results and concluded that he should replace his pigs’ usual food with food **B**.  
Evaluate this conclusion.

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**(4)**

**(Total 15 marks)**

**Q17.**(a)     Explain how oxygen is loaded, transported and unloaded in the blood.

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**(6)**

Midges are very small insects. The early stages of the life cycle of midges are called larvae. Midge larvae live in water. A biologist investigated the uptake of oxygen by the larvae of two species of midge. He measured the rate of uptake of oxygen by the larvae in water containing different concentrations of oxygen. The table shows his results.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Concentration of oxygen in water / cm3dm-3** | **Mean rate of oxygen uptake / cm3g-1h-1** | |
|  | *Chironomus longistylus* | *Tanytarsus brunnipes* |
|  | 1 | 220 | 141 |
|  | 2 | 285 | 246 |
|  | 3 | 304 | 342 |
|  | 4 | 313 | 362 |
|  | 5 | 320 | 367 |
|  | 6 | 318 | 430 |
|  | 7 | 320 | 469 |

(b)     The larvae in this investigation were kept at a temperature of 17 °C. Why was it important that the larvae of both species were kept at the same temperature?

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**(2)**

(c)     Describe the effect of an increase in oxygen concentration on the mean rate of oxygen uptake in *Chironomus longistylus*.

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**(2)**

(d)     *Chironomus longistylus* lives in still water whereas *Tanytarsus brunnipes* lives in fast running streams. The water in fast running streams has a higher concentration of oxygen than in still water. Use the table in part (a) to suggest how *Chironomus longistylus* is better adapted than *Tanytarsus brunnipes* to living in still water.

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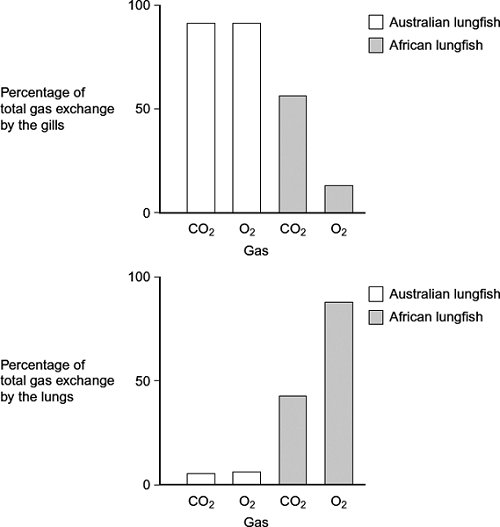
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**(2)**

(e)     Lungfish are freshwater fish which have gills and lungs. Scientists investigated how Australian and African lungfish use their lungs and gills for gas exchange. The graphs show the results of this investigation.



(i)      Describe the difference in the way carbon dioxide is lost from the body of an Australian lungfish and an African lungfish.

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**(1)**

(ii)     African lungfish are likely to survive for longer than Australian lungfish when living in pools that dry up. Explain why.

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**(2)**

**(Total 15 marks)**

**Q18.**The photograph shows marram grass growing on a sand dune.



Marram grass on sand dune by Nigel Chadwick [CC-BY-SA], via Wikimedia Commons

(a)     Describe how you would investigate the distribution of marram grass from one  
side of the dune to the other.

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**(3)**

(b)     Marram grass is a pioneer species that grows on sand dunes. It has long roots  
and a vertically growing stem that grows up through the sand.  
Sand dunes are easily damaged by visitors and are blown by the wind. Planting  
marram grass is useful in helping sand dune ecosystems to recover from damage.

Use your knowledge of succession to explain how.

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**(2)**

**(Total 5 marks)**

**Q19.**Ecologists studied a community of fish in a lake.

(a)     Explain what is meant by a community.

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**(1)**

(b)     (i)      The ecologists could have used the mark-release-recapture method to estimate the number of one species of fish in the lake. Describe how.

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**(3)**

(ii)     This species of fish breeds at a certain time of the year. During this fish-breeding season, the mark-release-recapture technique might **not** give a reliable estimate.  
Suggest **one** reason why.

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**(1)**

(c)     The ecologists found that each species of fish had adaptations to its niche. One of these adaptations was the shape of its mouth.

Suggest how the shape of mouth is an adaptation to its niche.

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**(2)**

**Q20.**Scientists investigated the effect of drinking tea and coffee on reducing the risk of developing one type of brain cancer. The investigation involved 410 000 volunteers and was conducted in 10 European countries over a period of 8.5 years.

(a)     (i)      Apart from age, suggest **two** factors that the scientists should have considered when selecting volunteers for this trial.

1 ............................................................................................................

2 ............................................................................................................

**(2)**

(ii)     Give **two** features of the design of this investigation that would ensure the reliability ofthe results obtained.

1 ............................................................................................................

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2 ............................................................................................................

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**(2)**

(b)     The incidence for this type of brain cancer is 6 cases per 100 000 per year.  
Use this information to calculate the expected number of volunteers developing this cancer during the 8.5 year period of this investigation. Show your working.

                Answer..................................................................................

**(2)**

(c)     In analysing the results of this investigation, the scientists took into account the age of the volunteers. Suggest why.

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**(1)**

(d)     During the investigation, the volunteers were asked to estimate the volume of tea and/or coffee that they drank each day. The types of tea and coffee consumed in different countries varied. When the data from all the countries were collected there was a correlation between drinking more than 100 cm3of tea or coffee each day and a reduced risk of developing this type of brain cancer.

Tea and coffee contain caffeine. A newspaper reported the results of this investigation under the headline ‘Caffeine helps cut cancer risk’. Explain why scientists could **not** support this view solely on the basis of this investigation.

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**(4)**

(e)     Another group of scientists investigated the effect of caffeine on blood flow to certain parts of the brain. Volunteers were given different concentrations of caffeine solution to drink. A control group was also set up.

(i)      Describe how the control group should have been treated.

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**(2)**

(ii)     Volunteers who drank the same concentration of caffeine solution often had different concentrations of caffeine in their blood. Suggest **one** reason for the difference in concentration of caffeine in the blood of volunteers.

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**(1)**

(iii)    The investigation showed that caffeine reduces the blood flow to certain parts of the brain. Suggest **one** way in which this could lead to a reduced risk of brain cancers.

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**(1)**

**(Total 15 marks)**

**Q21.**          A scientist investigated the uptake of radioactively labelled carbon dioxide in chloroplasts. She used three tubes, each containing different components of chloroplasts. She measured the uptake of carbon dioxide in each of these tubes.  
Her results are shown in the table.

|  |  |  |
| --- | --- | --- |
| **Tube** | **Contents of tube** | **Uptake of radioactively labelled CO2 / counts per minute** |
| **A** | Stroma and grana | 96 000 |
| **B** | Stroma, ATP and reduced NADP | 97 000 |
| **C** | Stroma | 4 000 |

(a)     Name the substance which combines with carbon dioxide in a chloroplast.

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**(1)**

(b)     Explain why the results in tube **B** are similar to those in tube **A**.

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**(1)**

(c)     Use the information in the table to predict the uptake of radioactively labelled carbon dioxide if tube **A** was placed in the dark. Explain your answer.

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**(2)**

(d)     Use your knowledge of the light-independent reaction to explain why the uptake of carbon dioxide in tube **C** was less than the uptake in tube **B**.

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**(2)**

(e)     DCMU is used as a weed killer. It inhibits electron transfer during photosynthesis. The addition of DCMU to tube **A** decreased the uptake of carbon dioxide. Explain why.

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**(2)**

**(Total 8 marks)**

**Q22.**Catalase is used in a number of industrial processes. It is normally obtained from a fungus called *Aspergillus niger*. Scientists produced a mutant strain of *A*. *niger* called K30. They wanted to know if this mutant strain produced more catalase than the normal strain of *A*. *niger*.

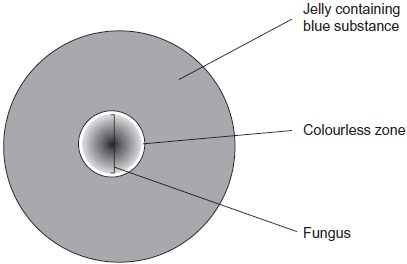
•        The scientists grew samples of the normal strain of the fungus and of the K30 strain on jelly in separate Petri dishes. The jelly contained a blue substance which is turned colourless by catalase.

•        They incubated the dishes for 3 days then measured the diameter of the colourless zone around the fungus.

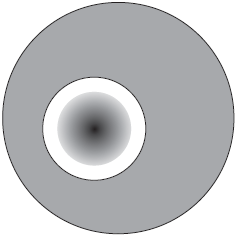
•        They calculated the ratio of the diameter of the colourless zone to the diameter of the fungus.

The diagram shows the dishes after incubation.

**Normal  
strain**



**K30 strain**



(a)     The scientists grew both strains of fungi on dishes kept at 30 °C. Keeping the dishes at a temperature of 15 °C would affect the results. Use your knowledge of kinetic energy to explain why.

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**(2)**

(b)     (i)      The scientists gave their results as ratios. Explain the advantage of giving the results of this investigation as a ratio.

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**(2)**

(ii)      For the normal strain the ratio of the diameter of the colourless zone to the diameter of the fungus was 1.1 : 1.

Calculate the ratio of the diameter of the colourless zone to the diameter of the fungus for the K30 strain. Show your working.

Ratio = ...................................................

**(2)**

(c)     The catalase produced by the K30 strain of the fungus is mainly an extracellular enzyme. This means that the fungus secretes catalase from its cells into the jelly in the Petri dish.

Describe and explain the evidence from the investigation which shows that the catalase is an extracellular enzyme.

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**(2)**

**(Total 8 marks)**

**Q23.**          Scientists investigated the response of the roots of pea seedlings to gravity.

They took three samples of seedlings, **A**, **B**, and **C**, and placed them so that their roots were growing horizontally. The root tips of each sample had been given different treatments. After a set time, the scientists recorded whether the roots of the seedlings had grown upwards or downwards and the amount of curvature. The table shows the treatment they gave to each sample and their results.

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Results** | |
| **Direction of growth** | **Mean amount of curvature / degrees** |
| **A** None | Downwards | 60 |
| **B** Root tip removed | Continues to grow horizontally | 0 |
| **C** Upper half of root tip removed | Downwards | 30 |

(a)     The pea seedlings were kept in the dark after each treatment. Explain why this was necessary.

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**(1)**

(b)     What conclusion can be made from the results for treatment **B**?

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**(1)**

(c)     Suggest how indoleacetic acid (IAA) could have caused the results for

(i)      treatment **A**

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**(2)**

(ii)     treatment **C**.

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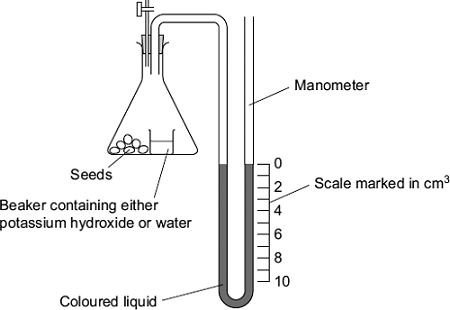
**(2)**

**(Total 6 marks)**

**Q24.**          A student investigated the rate of gas exchange in aerobically respiring seeds using the apparatus shown in the diagram. She carried out two experiments.

•        In Experiment **1**, she put potassium hydroxide solution in the beaker. Potassium hydroxide solution absorbs carbon dioxide.

•        In Experiment **2**, she put water in the beaker.



(a)     Both experiments were carried out at the same temperature. Explain why.

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**(2)**

(b)     (i)      The level of coloured liquid in the right-hand side of the manometer tube went down during Experiment **1**. Explain why.

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**(3)**

The results from both experiments are shown in the table.

|  |  |  |
| --- | --- | --- |
| **Experiment** | **Solution in beaker** | **Fall in volume of coloured liquid in right-hand side of manometer / cm3** |
| **1** | Potassium hydroxide | 5 |
| **2** | Water | 1 |

(ii)     Use these results to calculate the volume of carbon dioxide produced during Experiment **1**.

                                                  Answer = ..................................... cm3

**(1)**

(c)     The student repeated Experiment 1 using seeds which were respiring anaerobically.  
What would happen to the level of coloured liquid in the right-hand side of the manometer tube? Explain your answer.

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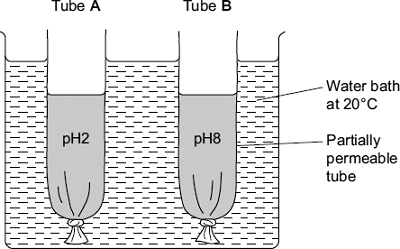
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**(2)**

**(Total 8 marks)**

**Q25.**          (a)     A student investigated the effect of pH on the activity of the enzyme amylase.  
She set up the apparatus shown in the diagram.



The tubes were made from Visking tubing. Visking tubing is partially permeable.  
She added an equal volume of amylase solution and starch to each tube.

•        She added a buffer solution at pH2 to tube **A**.

•        She added an equal volume of buffer solution at pH8 to tube **B**.

After 30 minutes, she measured the height of the solutions in both tubes.  
She then tested the solutions in tubes **A** and **B** for the presence of reducing sugars.

Describe how the student would show that reducing sugars were present in a solution.

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**(3)**

(b)     After 30 minutes, the solution in tube **B** was higher than the solution in tube **A**.

(i)      Explain why the solution in tube **B** was higher.

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**(3)**

(ii)     The student concluded from her investigation that the optimum pH of amylase was pH8. Is this conclusion valid? Explain your answer

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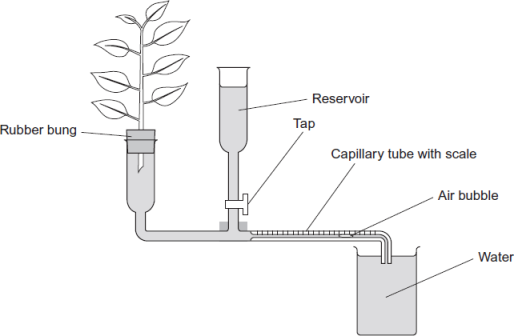
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**(1)**

**(Total 7 marks)**

**Q26.**Students investigated the effect of removing leaves from a plant shoot on the rate of water uptake. Each student set up a potometer with a shoot that had eight leaves. All the shoots came from the same plant. The potometer they used is shown in the diagram.



(a)     Describe how the students would have returned the air bubble to the start of the capillary tube in this investigation.

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**(1)**

(b)     Give **two** precautions the students should have taken when setting up the potometer to obtain reliable measurements of water uptake by the plant shoot.

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2......................................................................................................................

**(2)**

(c)     A potometer measures the rate of water uptake rather than the rate of transpiration. Give **two** reasons why the potometer does **not** truly measure the rate of transpiration.

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2......................................................................................................................

**(2)**

(d)     The students’ results are shown in the table.

|  |  |  |
| --- | --- | --- |
|  | **Number of leaves removed from the plant shoot** | **Mean rate of water uptake /  cm3 per minute** |
|  | 0 | 0.10 |
|  | 2 | 0.08 |
|  | 4 | 0.04 |
|  | 6 | 0.02 |
|  | 8 | 0.01 |

Explain the relationship between the number of leaves removed from the plant shoot and the mean rate of water uptake.

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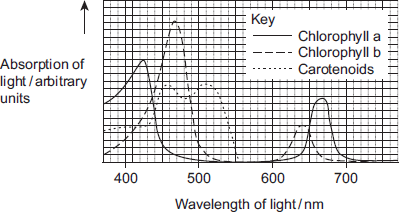
**(3)**

**(Total 8 marks)**

**Q27.**Plants have pigments that absorb light energy for photosynthesis. These pigments include two types of chlorophyll and a group of pigments known as carotenoids. Different species of plant contain different amounts of these pigments. The pigments that each plant species has are adaptations to where and how they live; their ecological niche.

**Figure 1** shows the absorption of light of different wavelengths by chlorophyll a, chlorophyll b and carotenoids.

**Figure 1**

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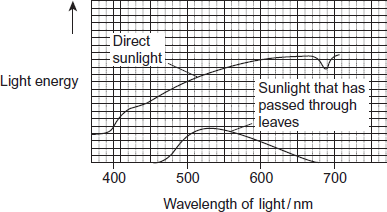
A scientist investigated the energy in light of different wavelengths reaching the ground in a forest. She measured the energy in

•        direct sunlight

•        sunlight that had passed through the leaves of trees.

**Figure 2** shows her results.

**Figure 2**

****

Beech trees have two types of leaves called sun leaves and shade leaves. Sun leaves grow on branches exposed to direct sunlight, shade leaves grow on branches exposed to light that has passed through leaves. An ecologist collected sun leaves and shade leaves from beech trees and determined the mean mass of each photosynthetic pigment in both types of leaf. His results are shown in **Figure 3**.

**Figure 3**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Photosynthetic pigment** | **Mean mass of each pigment per m2 of leaf  area / μg (± standard deviation)** | |
|  | **Sun leaves** | **Shade leaves** |
|  | Chlorophyll a | 299.3 (± 2.1) | 288.9 (± 0.1) |
|  | Chlorophyll b | 90.7 (± 2.1) | 111.1 (± 0.1) |
|  | Carotenoids | 0.10 (± 0.01) | 0.07 (± 0.01) |

(a)     It is an advantage to beech trees to produce more chlorophyll b in the shade leaves.

Suggest and explain why.

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**(2)**

(b)     There are two hypotheses about the advantage to plants of producing carotenoids.

**Hypothesis 1**

Carotenoids help shade leaves to absorb more light of wavelengths 480 nm to 520nm for photosynthesis.

**Hypothesis 2**

Carotenoids prevent damage to chlorophyll from very bright light.

(i)      Which hypothesis do the data provided on the resource sheet support?

Explain your answer.

Hypothesis ....................................

Explanation ............................................................................................

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**(2)**

(ii)     Suggest **one** other piece of experimental evidence you would need in order to be more confident about drawing your conclusion in (b)(i).

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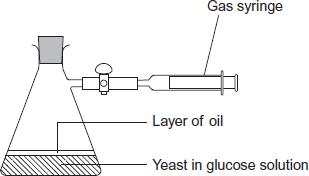
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**(1)**

**(Total 5 marks)**

**Q28.**A student investigated the rate of anaerobic respiration in yeast. She put 5 g of yeast into a glucose solution and placed this mixture in the apparatus shown in the figure below.  
She then recorded the total volume of gas collected every 10 minutes for 1 hour.



(a)     Explain why a layer of oil is required in this investigation.

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**(1)**

(b)     The student’s results are shown in the following table.

|  |  |  |
| --- | --- | --- |
|  | **Time / minutes** | **Total volume of gas collected / cm3** |
|  | 10 | 0.3 |
|  | 20 | 0.9 |
|  | 30 | 1.9 |
|  | 40 | 3.1 |
|  | 50 | 5.0 |
|  | 60 | 5.2 |

(i)      Calculate the rate of gas production in cm3 g–1 min–1 during the first 40 minutes of this investigation. Show your working.

Answer = ................... cm3 g–1 min–1

**(2)**

(ii)     Suggest why the rate of gas production decreased between 50 and 60 minutes.

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**(1)**

(iii)    Yeast can also respire aerobically. The student repeated the investigation with a fresh sample of yeast in glucose solution, but without the oil. All other conditions remained the same.  
Explain what would happen to the volume of gas in the syringe if the yeast were only respiring aerobically.

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**(2)**

(c)     Respiration produces more ATP per molecule of glucose in the presence of oxygen than it does when oxygen is absent. Explain why.

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**(2)**

**(Total 8 marks)**

**Q29.**Some mice have diabetes. The diabetes causes the blood glucose concentration to become very high after a meal. Scientists investigated the use of an inhibitor of amylase to treat diabetes.

The scientists took 30 mice with diabetes and divided them into two groups, **A** and **B**.

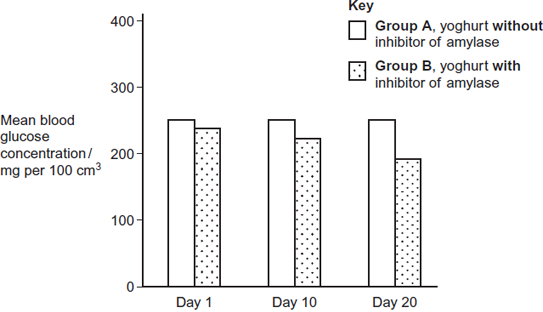
•        **Group A** was given yoghurt **without** the inhibitor of amylase each day.

•        **Group B** was given yoghurt **with** the inhibitor of amylase each day.

Apart from the yoghurt, all of the mice were given the same food each day.

The scientists measured the blood glucose concentration of each mouse, 1 hour after it had eaten. This was done on days 1, 10 and 20 after the investigation started.

The following figure shows the scientists’ results.

  
        Days after the investigation started

(a)     **Group A** acted as a control in this investigation.

Explain the purpose of this group.

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**(2)**

(b)     Apart from the yoghurt, it was important that all of the mice were given the same food each day.

Give **two** reasons why it was important that all of the mice were given the same food each day.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

(c)     The scientists’ hypothesis was that adding the inhibitor of amylase to the food would lead to a lower blood glucose concentration.

Use your knowledge of digestion to suggest how the addition of the inhibitor could lead to a lower blood glucose concentration.

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**(2)**

(d)     Give **one** reason why these results may **not** support the use of the inhibitor of amylase to treat diabetes in mice.

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**(2)**

**(Total 8 marks)**

**Q30.**Researchers investigated whether the blood supply to slow and fast muscle fibres in a muscle changes with age. They used diaphragms taken from hamsters (*Mesocricetus auratus*). The diaphragm is in constant use for breathing. They took diaphragms from groups of young, adult and old hamsters.

They removed the diaphragm from each animal and took a sample of muscle tissue.They examined it under an optical (light) microscope. For each sample they selected several fields of view at random. In each field of view, they then counted the number of capillaries associated with each type of muscle fibre.

This allowed the researchers to calculate the mean number of capillaries for each type of muscle fibre, for each age group.

The table below shows the researchers’ results which include standard deviation (SD).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Hamster age group** | **Number of hamsters in group** | **Mean number of capillaries associated with each type of muscle fibre** | |
|  | **Slow fibres (± SD)** | **Fast fibres (± SD)** |
|  | **Young** | 9 | 3.4 (±0.8) | 4.0 (±0.8) |
|  | **Adult** | 10 | 4.7 (±0.2) | 6.3 (±0.4) |
|  | **Old** | 8 | 4.6 (±0.9) | 6.8 (±0.6) |

(a)     Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

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4 .....................................................................................................................

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**(4)**

(b)     The researchers examined the muscle of an animal in the **old** age group. They found one field of view containing only slow muscle fibres. They counted 69 capillaries in this field of view.

(i)      Use a calculation to estimate how many slow muscle fibres were visible in this field of view. Show your working.

Number of slow muscle fibres = ..........................................................

**(2)**

(ii)     The actual number of slow muscle fibres in the field of view was **not** the same as the number you calculated in question (i).

Give **one** reason why.

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**(1)**

(c)     A student read the report of the researchers’ investigation. She thought that the investigation was unethical but that a conclusion could still be made.

(i)      Suggest why she thought the investigation was unethical.

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**(1)**

(ii)     She concluded that age had a significant effect on the mean number of capillaries per fibre.

Evaluate this conclusion.

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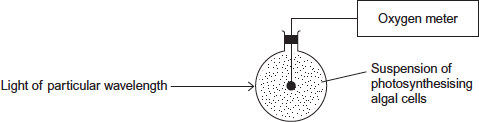
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**(4)**

**(Total 12 marks)**

**Q31.**A student investigated the effect of different wavelengths of light on the rate of photosynthesis. She used the apparatus shown in **Figure 1**.

**Figure 1**

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(a)     What measurements should the student have taken to determine the rate of photosynthesis?

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**(1)**

(b)     Other than temperature and pH, give **two** factors which should be kept constant during this investigation.

1 .....................................................................................................................

2 .....................................................................................................................

**(2)**

(c)     The student did **not** use a buffer to maintain the pH of the solution.   
Explain what would happen to the pH of the solution during this investigation.

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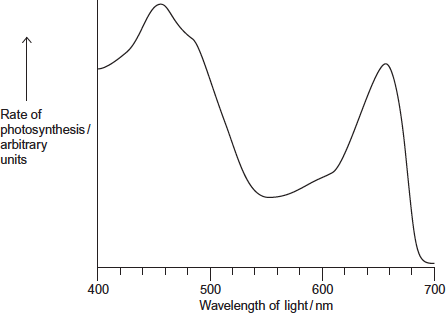
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**(2)**

(d)     **Figure 2** shows the student’s results.

**Figure 2**

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Suggest and explain why the rate of photosynthesis was low between 525 nm and 575 nm wavelengths of light.

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**[Extra space]** ................................................................................................

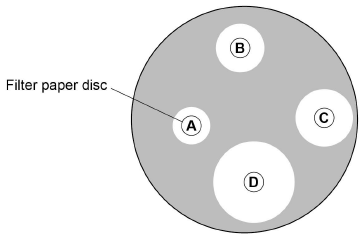
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**(2)**

**(Total 7 marks)**

**Q32.**A student investigated the effectiveness of four different concentrations, **A**, **B**, **C** and **D**, of the same disinfectant on the growth of a bacterium. He grew a culture of this bacterium on nutrient agar (a solid growth medium) in a Petri dish. The student then cut out four filter paper discs and soaked each disc in one of the four concentrations. He then placed the discs on the nutrient agar in the Petri dish. He then left the Petri dish at 25 °C for 24 hours.

The diagram below shows the appearance of the Petri dish after 24 hours.



(a)     Explain why there is a clear zone around each paper disc.

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**(1)**

(b)     The student researched information on this disinfectant prior to carrying out his investigation. On the basis of this research, the student used a maximum concentration of disinfectant of 40%.

Use the diagram to explain why.

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**(1)**

(c)     Suggest **two** variables the student should control in using the filter paper discs in this investigation.

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2 ..........................................................................................................................

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**(2)**

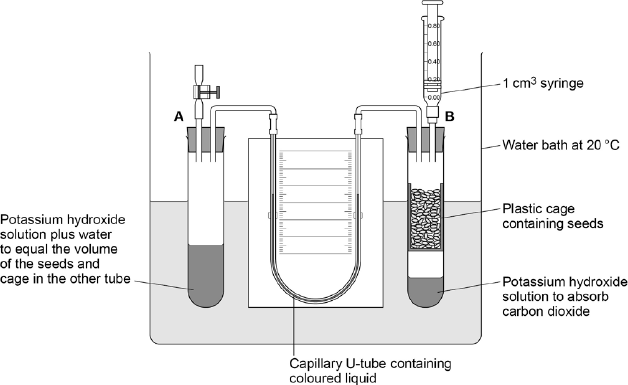
(d)     Use the areas of the clear zones in the diagram above to determine how many times more effective concentration **D** is than concentration **B**. Show your working.

Answer = ................................

**(2)**

**(Total 6 marks)**

**Q33.**The figure below shows the apparatus used for measuring the rate of oxygen consumption in aerobic respiration by seeds.



(a)     For the first 10 minutes, the tap attached to tube **A** was left open and the syringe from tube **B** was removed.

Suggest **three** reasons why the apparatus was left for 10 minutes.

1 .....................................................................................................................

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2 .....................................................................................................................

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3 .....................................................................................................................

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**(3)**

(b)     Suggest and explain why the chosen temperature was 20 °C for this experiment.

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**(2)**

After 10 minutes, the tap attached to tube **A** was closed and the syringe was attached to tube **B**. Every minute, the syringe plunger was moved until the levels in the U-tube were the same. The reading on the syringe volume scale was then recorded.

The results are shown in the table below.

|  |  |  |
| --- | --- | --- |
|  | **Time / minutes** | **Reading on syringe  volume scale / cm3** |
|  | 0 | 0.84 |
|  | 1 | 0.81 |
|  | 2 | 0.79 |
|  | 3 | 0.76 |
|  | 4 | 0.73 |
|  | 5 | 0.70 |
|  | 6 | 0.68 |
|  | 7 | 0.66 |
|  | 8 | 0.63 |
|  | 9 | 0.62 |
|  | 10 | 0.58 |

(c)     During the experiment, the coloured liquid in the tubing moved towards tube **B**.  
Explain what caused this.

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**(Extra space)** ................................................................................................

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**(3)**

(d)     The mass of the seeds was 1.6 g. Use the information in the table above to calculate the rate of oxygen consumption in cm3 g–1 hour–1 by the seeds.

Show your working.

Rate = .................................................................................. cm3 g–1 hour–1

**(2)**

**(Total 10 marks)**

**Q34.**The figure below shows a test that has been developed to find out if a person has antibodies to the human immunodeficiency virus (HIV) antigen.

|  |  |  |
| --- | --- | --- |
|  | **Step 1** | HIV antigens are attached to a test well in a dish. |
|  |  |  |
|  | **Step 2** | A sample of blood plasma is added to the well. If HIV antibodies are present, they bind to the HIV antigen. |
|  |  |  |
|  | **Step 3** | The well is washed. A second antibody with an enzyme attached is then added. This binds specifically to the HIV antibody. |
|  |  |  |
|  | **Step 4** | The well is washed again. A yellow solution is added, which changes to blue if the enzyme is present. A blue colour shows that the person has HIV antibodies. |

(a)     This test only detects the presence of HIV antibodies. Give **two** reasons why it cannot be used to find out if a person has AIDS.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

(b)     The solution will remain yellow if a person is **not** infected with HIV. Explain why.

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**(2)**

(c)     A mother who was infected with HIV gave birth to a baby. The baby tested positive using this test. This does not prove the baby is infected with HIV.  
Explain why.

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**(2)**

(d)     A control well is set up every time this test is used. This is treated in exactly the same way as the test wells, except that blood plasma is replaced by a salt solution.

Use information from the figure above to suggest **two** purposes of the control well.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

**(Total 8 marks)**

**Q35.**A group of students carried out an investigation to find the water potential of potato tissue.

The students were each given a potato and 50 cm3 of a 1.0 mol dm−3 solution of sucrose.

•        They used the 1.0 mol dm−3 solution of sucrose to make a series of different concentrations.

•        They cut and weighed discs of potato tissue and left them in the sucrose solutions for a set time.

•        They then removed the discs of potato tissue and reweighed them.

The table below shows how one student presented his processed results.

|  |  |  |
| --- | --- | --- |
|  | **Concentration of sucrose solution / mol dm−3** | **Percentage change in mass of potato tissue** |
|  | 0.15 | +4.7 |
|  | 0.20 | +4.1 |
|  | 0.25 | +3.0 |
|  | 0.30 | +1.9 |
|  | 0.35 | −0.9 |
|  | 0.40 | −3.8 |

(a)     Explain why the data in the table above are described as **processed** results.

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**(1)**

(b)     Describe how you would use a 1.0 mol dm−3 solution of sucrose to produce 30 cm3 of a 0.15 mol dm−3 solution of sucrose.

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**(2)**

(c)     Explain the change in mass of potato tissue in the 0.40 mol dm−3 solution of sucrose.

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**(2)**

(d)     Describe how you would use the student’s results in the table above to find the water potential of the potato tissue.

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**(Extra space)** .................................................................................................

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**(3)**

**(Total 8 marks)**

**M1.**(a)     1.      (before reaction) active site not complementary to/does   
not fit substrate;

2.      Shape of active site changes as substrate binds/as   
enzyme-substrate complex forms;

*Note. Points 1 and 2 may be made in one statement and ‘complementary’ introduced at any point.*

*Points 1&2 – active site mentioned once applies for both points*

*Point 2 – Ignore references to how shape change is caused*

3.      Stressing/distorting/bending bonds (in substrate leading to reaction);

**2 max**

(b)     1.      Tangent to curve drawn;

*Tangent drawn at about 10 minutes*

2.      Value in range of 8 to 11;

*1 mark only for correct answer*

**2**

(c)     1.      (Rate of) increase in concentration of maltose slows as substrate/starch is used up

**OR**

High initial rate as plenty of starch/substrate/more E-S complexes;

*Reject ref. to amylase being used up*

2.      No increase after 25 minutes/at end/levels off because no substrate/starch left;

*Accept ‘little’*

*Ignore references to substrate a limiting factor*

**2**

(d)     1.      Make/use maltose solutions of known/different concentrations   
(and carry out quantitative Benedict’s test on each);

2.      (Use colorimeter to) measure colour/colorimeter value of each   
solution and plot calibration curve/graph described;

*Axes must be correct if axes mentioned, concentration on x-axis and colorimeter reading on y-axis*

3.      Find concentration of sample from calibration curve;

**3**

**[9]**

**M2.**(a)     Stomata per mm2 or cm2

**OR**

Number per mm2 or cm2;

*Accept: mm−2 or cm−2.*

*Reject: per μm2 or μm−2.*

*Reject: the use of a solidus / as being equivalent to per.*

*Ignore: ‘amount’.*

**1**

(b)     1.      Single/few layer(s) of cells;

*Accept: more/too many/overlapping.*

*‛Single layer’ without reference to cells/tissue should* ***not*** *be credited.*

2.      So light can pass through;

**2**

(c)     1.      Distribution may not be uniform

**OR**

So it is a representative sample;

*Accept: more/fewer stomata in different areas.*

*Ignore: anomalies/random/bias.*

2.      To obtain a (reliable) mean;

*Accept: ‘average’.*

**2**

(d)     1.      Hairs **so** ‘trap’ water vapour and water potential gradient decreased;

2.      Stomata in pits/grooves **so** ‘trap’ water vapour and water potential gradient decreased;

3.      Thick (cuticle/waxy) layer **so** increases diffusion distance;

4.      Waxy layer/cuticle **so** reduces evaporation/transpiration.

5.      Rolled/folded/curled leaves **so** ‘trap’ water vapour and water potential gradient decreased;

6.      Spines/needles **so** reduces surface area to volume ratio;

*1, 2 and 5. Accept: humid/moist air as ‛water vapour’ but* ***not*** *water/moisture on its own.*

*1, 2 and 5. Accept: diffusion gradient as equivalent to water potential gradient.*

*1, 2 and 5. Accept: less exposed to air as an alternative to water potential gradient.*

*6. Accept: spines/needles* ***so*** *‘reduce area’.*

**2 max**

(e)     1.      Water used for support/turgidity;

2.      Water used in photosynthesis;

3.      Water used in hydrolysis;

4.      Water produced during respiration;

**2 max**

**[9]**

**M3.**          (a)     Electrons transferred down electron transport chain;

Provide energy to take protons / H+ into space between membranes;

Protons / H+ pass back, through membrane / into matrix / through  
ATPase;

Energy used to combine ADP and phosphate / to produce ATP;

*Accept: alternatives for electron transport chain.*

**3 max**

(b)     (i)      Prevent damage to mitochondria caused by  
water / osmosis / differences in water potential;

*Accept: other terms that imply damage e.g. shrink / burst*

**1**

(ii)     Glucose is used / broken down during glycolysis in cytoplasm / not in mitochondria;

*Accept: ‘glucose is converted to pyruvate’ for description of breakdown*

Glucose cannot cross mitochondrial membrane / does not  
enter mitochondria;

*Accept: only pyruvate can*

**2**

(iii)    Terminal / final acceptor (in electron transport chain) / used to  
make water;

*Could be shown by symbols*

**1**

**[7]**

**M4.**Lay tape / rope at right angle / perpendicular to road;  
Take samples at regular / stated intervals;  
Using a quadrat;  
Count numbers / percentage cover of dandelions;  
Use several transects;

**4 max**

**[4]**

**M5.**          (a)     (i)      Taxis;

*Ignore references to positive and negative, and prefixes such as photo-  
Accept taxes / tactic  
Allow phonetic spelling*

**1**

(ii)     Moves towards stimulus / towards light;

*Direction must be correct.*

**1**

(b)     Gravity;

Antennae involved;

Doesn’t show light is involved / doesn’t respond to light as they are  
unable to see / as eyes are covered;

*Accept geotaxis*

**3**

(c)     Helps them to leave the soil / ground / reach the surface;

Disperse / produce new colonies;

Avoid competition;

**2 max**

**[7]**

**M6.**          (a)     (i)      Fewest people at site R as mean is lowest;

*Accept use of mean values to show 2.2 is the lowest*

Standard deviations do not overlap so significant / not due to chance;

*Accept use of values / description of standard deviation even in wording ‘standard deviation’ is not used*

**2**

(ii)     There was a probability of less than 0.05 / 5 in a hundred / 5%;

*In the context of less than  
Accept converse: probability of more than 95%*

That the difference was due to chance;

*Look for idea of difference (between sites)*

**2**

(b)     (i)      (Would not be reliable as) number of species is still increasing;

*Accept: has not reached peak / maximum or if shown by values*

**1**

(ii)     Idea of curve has flattened / no more species found so no benefit / no point / takes unnecessary time / takes unnecessary  
effort / can get same results with fewer quadrats;

*Basic idea is of minimising effort.*

*If values used reward idea rather than accuracy of numbers*

**1**

(c)     Combustion / would burn / cause loss of substances (other than water) / named substance / cause loss of dry mass;;

*Accept: only want water to be lost*

*Ignore: reference to decomposition*

**1**

(d)     Seaweeds / plants are producers / lower / first trophic level / animals are consumers / higher trophic level / feed on seaweeds;

*Accept relevant position in food chain as trophic level*

Loss of energy between trophic levels as a result of respiration / as heat;

*Accept: energy transfer is inefficient*

*Accept: description of trophic levels  
Accept: not all seaweed / eaten*

**2**

(e)     (i)      The site / site U with most people / 34.6 has the largest ratio / 3.24;

*Accept: as number of people increases, ratio increases*

(Large value of ratio due to) large biomass ÷ small number / large  
size ÷ small number / biomass greater than abundance;

*Explanation of seaweed ratio*

**2**

(ii)     1.      Fewer larger animals / more smaller animals where more people / more disturbance;

*Principle*

2.      0.09 linked to 34.6 / appropriate link between row 4 and row 1;:

*Use of data*

3.      Larger animals affected by human activity;

*Accept: converse*

4.      Smaller animals are young animals;

*Accept: converse*

5.      Fewer species of seaweed (with disturbance);

*Accept if shown by figures*

6.      (So) fewer niches / habitats (for large animals);

*Accept idea of disturbance / damage to niche / habitat*

**4 max**

**[15]**

**M7.**         (a)     (i)      1.      Oxygen taken up / used (by woodlouse);

2.      Carbon dioxide (given out) is absorbed by solution / potassium hydroxide;

3.      Decrease / change in pressure;

*Reference to vacuum negates last marking point*

*Reject reference to pressure increasing inside tube*

**3**

(ii)     1.      Distance (drop moves) and time;

2.      Mass of woodlouse;

3.      Diameter / radius / bore of tubing / lumen / cross-sectional area;

*If answer refers to measuring volume using the syringe allow 2 max –*

*one mark for measuring volume;*

*one mark for mass of woodlouse;*

**3**

(b)     1.      Less / no proton / H+ movement so less / no ATP produced;

2.      Heat released from electron transport / redox reactions / energy not used to produce ATP is released as heat;

3.      Oxygen used as final electron acceptor / combines with electrons (and protons);

**3**

**[9]**

**M8.**          (a)     Two marks for correct answer of 59 / 60;;

One mark for incorrect answer clearly derived from figures of 18, 28  
and 38;

*Ignore: any figures after decimal point.*

**2**

(b)     (i)      Population changes;

*Reject: population decreases*

As young birds leave nest / join population;

*Reject first point if (young) birds are leaving population / migrating*

**2**

(ii)     (Would be likely to) catch all birds (again) in second sample / sample sizes are the same;

*Neutral: references to breeding*

Birds (in territories and) not mixing with population;

*Accept: idea of the population is divided*

Accept only estimates number of birds in territories sampled / territory sample not representative (of population) for 1 mark

**2**

(c)     (Recording) DNA / base sequence is like marking (animal) / wouldn’t need to mark;

(Finding identical / same base sequence) would show animal has been caught / recorded before;

**2**

**[8]**

**M9.**(a)     Light (intensity) / temperature / air movement / humidity;

**1**

(b)     Prevent air entering / continuous water column;

*Allow answer in context of shoot, xylem or potometer.*

**1**

(c)     Distance and time;

*Reject ‘amount bubble moves’*

**1**

Radius / diameter / area (of capillary tube);

**1**

(d)     (used to provide) turgidity / support / description of;

(used in) photosynthesis / (produced in) respiration;

Apparatus not sealed / ’leaks’;

**2 max**

(e)     (i)      Returns bubble (to start);

**1**

(ii)     Increases reliability (of results) / anomalous result can be identified;

***Q*** *Ignore references to validity / precision / accuracy etc.*

**1**

**[8]**

**M10.**          (a)     (i)      Healthy volunteers have ‘normally’ functioning vessels;

***OR***

Blood vessel / lumen / diameter not affected by other factors / is of normal size;

*Accept: a valid ethical argument  
e.g. treatment does not harm healthy volunteers*

*Reject: ref. to change in artery thickness*

*Accept: converse arguments for unhealthy volunteers*

*Must be related to this investigation*

*Neutral: to ensure that that the results are due to the independent variable*

**1**

(ii)     Avoids bias / selection (by scientists);

*Neutral: ref. to having the same number / gender / age of people in each group;*

**1**

(b)     (i)      Same as experimental group;

Chocolate with no flavenoids;

*Neutral: no dark chocolate*

*Neutral: placebo*

*Reject: milk chocolate*

*Neutral: ref. to fair testing*

**2**

(ii)     (To ensure that results are) not due to some other substance in the chocolate / due to flavenoids (only);

*Must be related to this investigation*

*Neutral: to ensure that the results are due to the independent variable*

*Neutral: to show results are not due to other factors*

*Neutral: to show results are only due to the chocolate*

*Neutral: to compare results for people who did and did not have flavenoids*

**1**

**[5]**

**M11.**          (a)     (i)      Increase to 30 °C / 31 °C and then decreases / optimum or max rate at 30 °C / 31 °C;

*Accept: peak at 30 °C / 31 °C*

**1**

(ii)     1.      Enzyme denatured / hydrogen bonds / bonds holding tertiary structure broken / tertiary structure changed;

2.      Change in shape of active site (of enzymes);

3.      Substrate / protein no longer fits / binds (into active site) / few or no ES complexes;

*1. Reject: Peptide bonds broken*

*Denatures active site = 2 marks for mp 1 and 2*

*2. Q Only allow second point if active site is used correctly*

*Accept: active site no longer complementary*

*3. Accept: Substrate cannot bind to enzyme*

**3**

(b)     (i)      Use buffer / test pH (at end / at intervals);

*Accept a method of measuring pH.*

*Reject litmus.*

**1**

(ii)     (30 °C / 31 °C) Maximum rate / optimum temperature;

*Accept other valid answers e.g. temp below  
30 °C as enzyme not denatured.*

**1**

(iii)     Works best at pH 6 / at higher pH activity decreases;

*Accept converse*

*Insufficient: pH 6 had largest clear area*

**1**

**[7]**

**M12.**          (a)     (So results) can be compared / so measurement is the same each time / because eye is not perfectly round / uniform;

*Accept eye opens to different amounts*

**1**

(b)     (i)      1.      Eye (diameter) is smaller and antennae longer;

2.      Antennae detecting touch;

3.      Data only refers to shrimps / data may not apply to all animals / only in one area;

*The principle here is that candidate has recognised that both features confirm suggestion. Exact wording does not matter.*

**2 max**

(ii)     1.      Standard deviation gives a measure of spread / variation;

2.      More standard deviations overlap, the less likely it is that differences are real / significant / the more likely they are caused by chance;

*Do not accept range*

*Accept converse.*

*Although we are looking for the idea of significance, we cannot require this term.*

**2**

(c)     (i)      Qualitative statement about

          difference in size /

          difference in variation /

          overlap in size;

Quantitative statement about

          difference in size /

          difference in variation /

          overlap in size;

Supported by relevant two sets of figures from graph;;

*Note simplistic answer involving a quantitative statement gains 1 mark.*

*More specific answer involving quantitative information gains 2 marks.*

**2**

(ii)     (No) for same body length, antenna are longer / antenna are shorter / some with longer body have short antennae / some with shorter body length have longer antennae;

***OR***

(Yes) positive correlation in open / in cave;

*Habitat not critical as a term.*

*Must refer to idea of same habitat*

*Accept description*

**1**

(d)     More alleles of each gene / shrimps in open have all the alleles;

*Candidates are required to use the information from the table. Must therefore refer to alleles.*

**1**

(e)     1.      A small number of shrimps were / went into the cave;

2.      All / high proportion of shrimps had allele L;

3.      Cave population descended from these / these reproduce;

**3**

(f)      (i)      1.      Cross shrimps from two sites / watch courtship;

2.      Breed young together / observe mating;

3.      Allow 1 mark for any method of improving quality of results e.g. carry out reciprocal crosses / large number of crosses / isolate beforehand;

*Other valid equivalent suggestions should be accepted.*

(ii)     If same species the shrimps would breed, producing fertile young / courtship species specific;

*Accept any form of evidence – mating / laying eggs / giving birth to young.*

**3**

**[15]**

**M13.**          (a)     Water will affect the mass / only want to measure water taken up or lost;

Amount of water on cylinders varies / ensures same amount of water on outside;

*Neutral: removes water*

*Accept: ‘(sodium chloride) solution’ for water*

*Do not accept ‘sodium chloride’*

*Neutral: refs. to fair testing*

**2**

(b)     4 cm3 (of 1.0 mol dm–3 sodium chloride solution) and 16 cm3 (of distilled water);

*Reject: factors and multiples of these figures e.g. 2 cm3 and 8 cm3, as final volume should be 20 cm3*

**1**

(c)     Allows comparison / shows proportional change;

Idea that cylinders have different starting masses / weights;

*Reject: if comparison is in context of the start and final mass of the same cylinder*

*Neutral: different masses*

*Neutral: different starting sizes*

**2**

(d)     (Allows) anomalies to be identified / ignored / effect of anomalies to be reduced / effect of variation in data to be minimised;

Makes the average / mean / line of best fit more reliable / allows concordant results;

*Accept: ‘outliers’ instead of anomalies*

***Q*** *Reject: abnormalities*

*Reject: idea of not recording anomalies / preventing anomalies from occurring*

*Accept: ‘cancels out anomalies’ as bottom line response*

***Q*** *Reject: makes the average / mean more accurate*

*Neutral: makes the average / mean more valid*

*Neutral: makes ‘it’ / results / conclusion more reliable*

**2**

(e)     0.35 (mol dm–3)

**1**

**[8]**

**M14.**          (a)     Light;

Humidity / moisture in air;

Air movement / wind;

Temperature;

**2 max**

(b)     Decreases chance of error / larger difference in mass / improves  
accuracy / precision;

*Neutral: Reliability, references to anomalies.*

**1**

(c)     1.      Stomata open, (water) transpired / evaporates / diffuses out (via) water potential gradient / leaf has higher water potential;

2.      Water potential / diffusion gradient reduces (during investigation) as water not being replaced / no water supply;

3.      Stomata close / closing;

*Must clearly indicate that stomata are open for third marking point. However, allow correct descriptions of guard cells being turgid or flaccid as being equivalent to stomata being open or closed. ‘Loss through stomata’ on its own is not sufficient.*

*Neutral: Any reference to ‘loss by osmosis’.*

**3**

(d)     Stomata (on upper surface) covered / stomata close due to lack of  
light / (grease provides) longer diffusion pathway;

Less evaporation / transpiration / diffusion out;

*Accept: Evaporation / transpiration / diffusion ‘stops’ for second point as this could be referring to upper surface.*

**2**

**[8]**

**M15.**          (a)     1.      Uses energy / ATP;

2.      Against concentration gradient / low to high concentration;

3.      Does not use channel proteins / only uses carrier proteins;

*Assume “it” refers to active transport.*

*1. Facilitated diffusion is passive - neutral*

*2. Along / across concentration gradient - neutral*

*Accept up / down concentration gradient*

*Accept AT does not need concentration gradient.*

**2 max**

(b)     (i)      To see the effect of the drug / effect not due to anything else in the tablet;

*Neutral “to compare results”*

**1**

(ii)     Placebo / dummy drug / tablet without drug;

(Otherwise) treated the same;

*No drug - neutral*

*Accept: Example e.g. tablet given at same time*

**2**

(c)     Decrease for 3 hours;

*Accept decreases from 1 - 4 hours*

**1**

**[6]**

**M16.**         (a)     (i)      1.      Same breed so similar alleles;

*1.  Allow different alleles have different effects*

2.      Controls / removes variable / so genes not a factor / only temperature affects results / rate of growth affected by genes;

*2. Accept idea worded in such terms as inherited.*

**2**

(ii)     1.      Different growth rates / gained different biomass / grew different amount;

*Allow “more food for growth”*

*Ignore references to efficiency of conversion.*

2.      Not due to temperature / the independent variable;

**2**

(b)     (i)      Rise then fall with peak at 20 C;

*Do not accept 0.85 as alternative to 20.*

**1**

(ii)     1.      Temperature may be between 10 and 30 / 10 and 20 / 20 and 30;

*No mark for yes or no.*

2.      Intervals are 10°C / large / not small / should be smaller / should be intermediates;

**2**

(c)     (i)      1.      Growth rate decreasing / conversion staying same / decreasing;

2.      (Scientists would be) looking for high growth rate / conversion / data shows unlikely to improve growth / yield;

3.      Wastes time / resources / would not relate to farming conditions;

*3. Ignore cruelty to pigs*

**2 max**

(ii)     1.      Will lose more heat / not as much energy used to maintain body temperature;

*1. Must be a comparative statement*

*Accept energy as equivalent to heat in the context of this question*

2.      Heat resulting from respiration / more respiration;

*2. Do not credit answers relating to energy made in respiration*

3.      More food used in respiration;

**2 max**

(d)     **In support**

*Read standard deviation as standard error*

1.      Food **B** produces greater mass than control / greater than 100%;

*1. Must refer to control*

**But**

2.      Error bars for **B** mean **B** could be no better / not different from control;

3.      Overlap of error bars for **B** and **A**;

4.      A no better than / not different from **B**;

*4. Neutral: “Results not significant”. Mark must compare* ***A*** *to* ***B***

**Experimental limitations**

5.      Experiment only ran for 10 days;

6.      Experimental conditions / breed of pig may not be the same as on the farm;

7.      No information about cost;

**4 max**

**[15]**

**M17.**(a)     1.      Haemoglobin carries oxygen / has a high affinity for oxygen / oxyhaemoglobin;

2.      Loading / uptake / association in lungs;

3.      at high p.O2;

4.      Unloads / dissociates / releases to respiring cells / tissues;

5.      at low p.O2;

6.      Unloading linked to higher carbon dioxide (concentration);

*6. Ignore reference to incorrect pH in relation to effect of higher carbon dioxide concentrations for marking point*

**6**

(b)     1.      Allows comparison;

*Do not credit 'temperature affects results' on its own;*

2.      (Different temperature) affects enzymes;

*2. Allow reference to denaturation of enzymes.*

3.      (Different temperature) affects respiration / metabolism;

4.      (Different temperature) affects amount of dissolved oxygen;

**2 max**

(c)     1.      Increases then levels out / stops increasing / fluctuates slightly;

2.      At 5 (cm3 dm-3) / 320 (cm3 g-1h-1);

*Allow description of 'fluctuates slightly' in terms of candidate quoting figures after 320.*

**2**

(d)     1.      *Chronimus longistylus* has higher uptake at low (oxygen) concentrations;

*Chronimus longistylus has higher uptake to (oxygen concentration of) 2 / lower uptake after 2; (= 2 marks)*

2.      (Higher uptake) up to 2 cm3 dm-3;

*2. Award mark if candidate uses figures from table e.g. higher at concentration 1 (220) or concentration 2 (285).*

*Higher uptake at concentration 1 or 2 = 2 marks.*

**2**

(e)     (i)      More (than in African) lost via gills in Australian lungfish / less (than African) lost via lungs in Australian lungfish;

**1**

(ii)     1.      More / most exchange is via lungs (in African lungfish);

*1. Allow converse for first point.*

2.      Gills will not function / function less efficiently (in air);

*2. Allow water is required for gills to function.*

**2**

**[15]**

**M18.**          (a)     1.      Transect / lay line / tape measure (from one side of the dune to the other);

*1. & 2.   Reject random in context of placing transect / quadrats*

2.      Place quadrats at regular intervals along the line;

*Accept references to stratified sampling / different seral stages*

3.      Count plants / percentage cover / abundance scale (in quadrats)

*Accept abundance scale*

**OR**

         Count plants and record where they touch line / transect;

**3 max**

(b)     1.      Stabilises sand / stops sand shifting;

2.      Forms / improves soil / makes conditions less hostile;

*Allow credit for example of making conditions less hostile such as:*

*Adds nutrients*

*Improves water retention*

**2**

**[5]**

**M19.**(a)     All the fish / all the species / all the populations / all the organisms;

*Must indicate all / every species.*

*Reject answers that suggest other fish / organisms might be present.*

**1**

(b)     (i)      1.      Capture sample, mark and release;

2.      Appropriate method of marking suggested / method of marking does not harm fish;

*E.g. Cutting a fin / attaching a tag / paint / marker.*

3.      Take second sample and count marked organisms;

*May be awarded from equation if not given here.*

4.      

*Accept any valid alternative to equation or answer expressed as a ratio.*

**3 max**

(ii)     One suitable reason;

*Accept other valid answers, which must, however, relate to breeding / only works if population constant.*

E.g. population increases / changes (between first and second sample)

**1**

(c)     1.      With different mouth eats different food / has different way of feeding / specific mouth shape for specific food;

*Catches more food and gas exchange are neutral*

2.      Competition between species / interspecific competition is reduced;

*Reject intraspecific*

**2**

**[7]**

**M20.**(a)     (i)      1.      Sex;

2.      Lifestyle;

*Stress, smoking, diet etc are examples of lifestyle.*

3.      Body mass;

*3. Allow weight for mark point 3.*

4.      Health;

*Reject: height.*

5.      Ethnicity;

6.      Genetic factors / family history;

**2 max**

(ii)     1.      Large sample / number / 410 000;

*Reject: random*

2.      Long time period / 8.5 / many years;

3.      Different countries / more than one country;

**2**

(b)     Correct answer of 209 / 209.1 = 2 marks;

*Answer of 210 = one mark*

Incorrect answer but multiplies by 8.5 = 1 mark;

**2**

(c)     Age affects risk of cancer;

*Must relate to cancer not just to illness*

**1**

(d)     1.      Correlation does not mean causal relationship;

*1. Reject casual for point 1.*

*Reference to 'due to other factors' on its own is not enough for a mark*

2.      Tea / coffee contains other substances / different amounts of caffeine / estimated intake (of tea / coffee);

3.      No control group;

4.      Only one type of cancer studied / further studies required / only one investigation / study / group;

**4**

(e)     (i)      1.      Treated the same;

*2. Accept decaffeinated*

2.      No caffeine;

*2. Reject placebo.*

**2**

(ii)     1.      Absorb different amounts;

*Reject: Different body masses*

2.      Broken down by enzymes / digested;

3.      Different blood volumes;

4.      Differences in metabolism;

5.      Caffeine from a different source;

**1 max**

(iii)    1.      Less oxygen / glucose to (cancer) cells;

*'Reduces cell division' on its own should not be credited.*

2.      Less carcinogens;

3.      Reduces spread of cancer (cells);

**1 max**

**[15]**

**M21.**          (a)     Ribulose bisphosphate / RuBP;

*Accept Ribulose biphosphate or Ribulose diphosphate*

*Accept phonetic spellings*

*Accept any variation in upper or lower case for RuBP*

**1**

(b)     ATP and reduced NADP are produced in grana / thylakoids / present in A / both tubes;

*Must be reduced NADP but accept any alternative which show hydrogen attached to NADP*

*Must be reduced NADP not reduced NAD*

**1**

(c)     1.      4 000;

*Accept ‘same as in (tube) C’, but not ‘same’ on its own*

2.      Light-dependent reaction does not occur / ATP and reduced NADP are not produced;

*Accept converse for mark point 2*

**2**

(d)     1.      (Less) GP converted to TP;

*GP = glycerate 3-phosphate*

*TP = triose phosphate but abbreviations are sufficient*

2.      (Less) TP converted to RuBP;

*Accept GALP as TP*

**2**

(e)     1.      No / less ATP / ATP produced (during electron transport);

*Must be reduced NADP but accept any alternative which shows hydrogen attached to NADP*

2.      No / less reduced NADP / reduced NADP produced (during electron transport)

**2**

**[8]**

**M22.**(a)     ***EITHER***

*Answer either based on*

1.      Molecules move at slower speeds;

*2 diffusion or*

2.      Decreases rate of diffusion;

*4 enzymes.*

***OR***

3.      Molecules move at slower speed;

4.      Fewer collisions between enzymes and substrates / fewer enzyme-substrate complexes formed;

*Accept converse answers if clearly in context of “If it stayed at 30 C”.*

**2 max**

(b)     (i)      1.      Allows comparison;  
2. Different amounts of fungus added / fungus is different size at start;

**2**

(ii)     Two marks for correct answer in range 1.7 : 1 to 1.3 : 1;;

*Answer must be expressed this way round and must give the diameter of the fungus as 1.*

One mark for unsimplified answer in range 29 : 19 to 27 : 21;

*Calculations are based on tolerance limits for measurements of ± 1 mm. If the actual measurements are other than 28 and 20, marking guidelines should be adjusted accordingly.*

**2**

(c)     1.      Colourless zone around fungus / colourless zone outside fungus;

2.      No fungus growing here / must be enzyme here;

*Accept any alternative wording clearly relating to colourless zone.*

**2**

**[8]**

**M23.**          (a)     1.      (Seedlings) respond to light / are phototropic;

*Reject: roots are positively phototropic / grow towards light*

***OR***

*Neutral: ‘to control a variable’*

2.      (Only) measuring the effect of gravity / response to gravity;

*Neutral: light affects growth / results*

**1**

(b)     1.      (Cells in) root tip detect gravity / respond to gravity;

*Must refer to root tip and not just the root*

***OR***

2.      IAA / auxin is produced in the root tip;

**1**

(c)     (i)     1.      IAA / auxin moves to lower side / more IAA / auxin on lower side;

*Accept: references to ‘cell elongation’ instead of ‘growth’*

2.      Lower side grows less / slower / upper side grows more / faster / inhibits growth on lower side;

*Note: if auxin is placed at upper side, mark point 2 can still be awarded*

*Need idea of ‘less / slower’ or ‘more / faster’ for mark point 2*

**2**

(ii)     1.      Less IAA / auxin (produced);

2.      Lower side grows more / faster / less inhibition of growth on lower side;

*Must refer to the lower side*

**2**

**[6]**

**M24.**          (a)     1.      Affects enzymes;

*‘respiration involves enzymes’ = two marks*

2.      Affects respiration;

*Ignore reference to controlling a variable*

                 Or

3.      Affects volume / pressure of gases;

*Mark point 4 can only be awarded if mark point 3 has been credited*

4.      Affects readings;

**2 max**

(b)     (i)     1.      Oxygen taken up / used (by seeds);

*Reject air is taken up for mark point 1*

2.      Carbon dioxide (given out) is absorbed by solution / potassium hydroxide;

3.      Decrease in volume / pressure (inside flask);

*Reference to vacuum negates mark point 3*

**3**

(ii)     4;

**1**

(c)     1.      Remains the same;

2.      No oxygen uptake / used;

*Any reference to ‘carbon dioxide* ***not*** *being produced’ disqualifies mark point 2*

**2**

**[8]**

**M25.**          (a)     1.      Add Benedict’s;

*Hydrolyse with acid negates mp1*

2.      Heat;

*Accept warm, but not an unqualified reference to water bath*

3.      Red / orange / yellow / green (shows reducing sugar present);

*Accept brown*

**3**

(b)     (i)      1.      Starch hydrolysed / broken down / glucose / maltose produced;

*Neutral: Sugar produced*

2.      Lower water potential;

3.      Water enters by osmosis;

**3**

(ii)     Only 2 pHs studied / more pHs need to be tested;

*Accept: different amylase may have a different optimum pH*

**1**

**[7]**

**M26.**(a)     Open / use tap / add water from reservoir;

**1**

(b)     1.      Seal joints / ensure airtight / ensure watertight;

*Answer must refer to precautions when setting up the apparatus*

*Ignore: references to keeping other factors constant*

2.      Cut shoot under water;

3.      Cut shoot at a slant;

4.      Dry off leaves;

5.      Insert into apparatus under water;

6.      Ensure no air bubbles are present;

7.      Shut tap;

8.      Note where bubble is at start / move bubble to the start position;

**2 max**

(c)     1.      Water used for support / turgidity;

*Accept: water used in (the cell’s) hydrolysis or condensation (reactions) for one mark. Allow a named example of these reactions*

2.      Water used in photosynthesis;

3.      Water produced in respiration;

4.      Apparatus not sealed / ‘leaks’;

**2 max**

(d)     As number of leaves are reduced (no mark),

*Accept: converse arguments*

1.      Less surface area / fewer stomata;

3.      Less evaporation / transpiration;

4.      Less cohesion / tension / pulling (force);

**3**

**[8]**

**M27.**(a)     1.      (Some of the) light that passes through is absorbed  
         by chlorophyll b;

2.      This is light of around 500 and / or around 640;

*Accept any value or range between 460 and 540 and /   
or 600 and 670*

**2**

(b)     (i)      Supports hypothesis 2 (no mark)

1.      Greater carotenoid found in sun leaves than shade leaves of beech tree;

2.      Sun leaves exposed to much brighter light than shade leaves;

**OR**

It supports hypothesis 2 because it does not support hypothesis 1 (no mark)

3.      Although carotenoids absorb wavelengths of light that pass through leaves;

4.      There are not more carotenoids in shade leaves;

**2**

(ii)     1.      Mass of pigments / carotenoids in sun and shade leaves of other trees;

2.      Position of carotenoids in leaf cells;

3.      Effect of bright light on (isolated) chlorophyll;

4.      Whether without carotenoids chlorophyll is damaged (supporting hypothesis 2) / photosynthesis is reduced (supporting hypothesis 1);

**1 max**

**[5]**

**M28.**(a)     Prevents oxygen being taken up / entering / being absorbed;

*Accept: any idea of no contact with oxygen.*

*Neutral: for anaerobic respiration / anaerobic conditions.*

*Neutral: prevents entry of air.*

*Reject: prevents entry of oxygen and another named gas.*

**1**

(b)     (i)      0.0155 / 0.016 = 2 marks;;

0.0775 / 0.077 / 0.078 / 0.08 = 1 mark

/ 0.62 = 1 mark

**2**

(ii)     Glucose decreases / is a limiting factor / increase in ethanol / yeast / cells die / toxins build up;

*Accept: glucose is used up.*

**1**

(iii)    1.      (Stays the) same / level / (relatively) constant;

2.      Same volume / amount of oxygen uptake and carbon dioxide release;

*Note: if m.p.1 is awarded m.p 2 can be obtained without referring to ‘same volume / amount’.*

**2**

(c)     1.      Oxygen is final / terminal (electron) acceptor / oxygen combines with electrons and protons;

2.      Oxidative phosphorylation / electron transport chain provides (most) ATP / only glycolysis occurs without oxygen / no Krebs / no link reaction;

**2**

**[8]**

**M29.**(a)     1.      To show the effect of the inhibitor / drug;

2.      To show the effect of yoghurt (on its own does not affect blood  
glucose);

**2**

(b)     1.      Food is a factor affecting blood glucose / different foods contain   
different amounts of starch / glucose / sugar / carbohydrate;

*Accept converse*

2.      To keep starch / fibre intake the same / similar;

*Accept something in food which affects the inhibitor*

**2**

(c)     1.      Fewer E-S complexes formed;

2.      (With inhibitor) less / no starch digested to maltose ;

*Require knowledge that maltose comes from starch*

3.      (So) less / no glucose from maltose;

*Require knowledge that glucose comes from maltose*

*Accept no glucose*

4.      (So) less absorption of glucose (from gut);

**2 max**

(d)     **Suitable reason; with explanation;**

Paired responses – do not mix and match

*Ignore references to correlation does not prove causation,   
it could be due to other factors*

Examples,

1.      Need larger sample / only 30 mice / only 15 mice in each group;

*Accept small sample size*

2.      Might not be representative / anomalies might have a bigger or smaller effect;

*Accept mean not reliable*

***OR***

3.      Investigation only lasted 20 days;

*Experiment was not long enough*

4.      Can’t see what longer term effects are;

***OR***

5.      Fall in blood glucose is small / numbers from graph;

6.      Mice with inhibitor still have a large rise in blood glucose / so don’t know if differences significant;

*Accept differences are due to chance*

***OR***

7.      No stats / SDs / SEs;

8.      So don’t know if differences significant;

***OR***

9.       Blood glucose could continue to fall;

10.     which could be harmful;

***OR***

11.     No group without yoghurt;

12.     So cannot compare to other groups;

**2 max**

**[8]**

**M30.**(a)     1.      Fields of view randomly chosen;

2.      Several fields of view;

3.      All same species (of animal / hamster);

*Reject general statements related to sample size. All mark points relate directly to information provided in Resource A.*

*Accept ‘all (Mesocricetus) auratus’.*

4.      Same muscle / organ used / only diaphragm used;

5.      Used at least 8 (animals) in each (age) group.

**4 max**

(b)     (i)      15

*Correct answer = 2 marks.*

*Allow 1 mark for showing*

*69 ÷ 4.6*

*OR*

*answer of 10 / 10.1 (correct calculation using fast in error.)*

**2**

(ii)     1.      (Calculation) used mean (number of capillaries);

2.      Variation in number of capillaries per fibre.

*Note: maximum of* ***1*** *mark for this question.*

*Ignore reference to an anomaly or calculation errors.*

**1 max**

(c)     (i)      (Removing diaphragm means) animals / hamsters are killed.

**1**

(ii)     1.      (Suggests) significant (difference) between young and adult;

*MP1, MP2, MP4 and MP5 can include use of figures but check figures are used correctly.*

2.      (Suggests) not significant (difference) between adult and old;

*Statements related to ‘results being significant / not significant’ do not meet the marking points. It is the difference that is significant or not. However, only penalise this error once.*

3.      For slow **and** fast fibres;

*This MP can be given in the context of either MP1 or MP2 but only allow once. As well as this context there must be a reference to ‘both’ types of fibre.*

4.      (Suggests) significant (difference) between young and old for fast (fibres)  
OR  
(Suggests) not significant (difference) between young and old for slow (fibres);

*All aspects of either approach required to gain credit.*

5.      (Suggests) significant (difference) where means ± SD do not overlap  
OR  
(Suggests) not significant (difference) where means ± SD overlap;

*All aspects of either approach required to gain credit.*

6.      Stats test is required (to establish whether significant or not).

**4 max**

**[12]**

**M31.**(a)     Oxygen production / concentration and time.

*Accept: oxygen volume / concentration*

*Reject: oxygen uptake*

*Neutral: reference to carbon dioxide uptake*

**1**

(b)     1.      Intensity of light;

*Accept: distance from light*

2.      Amount / number / mass / species of algae / photosynthesising cells;

3.      Carbon dioxide (concentration / partial pressure);

4.      Time.

**2 max**

(c)     1.      (pH) increases;

*Neutral: becomes more alkaline / less acidic*

2.      As (more) carbon dioxide removed (for photosynthesis).

**2**

(d)     1.      Less absorption / (more) reflection (of these wavelengths of light);

*Reject: no absorption or cannot absorb unless in context of green light.*

*Note: no green light absorbed or green light reflected = 2 marks.*

2.      (Light required) for light dependent (reaction) / photolysis

*Accept: for excitation / removal of electrons (from chlorophyll)*

3.      (Represents) green light / colour of chlorophyll.

**2 max**

**[7]**

**M32.**(a)     Bacteria killed;

*Ignore: no growth or growth of bacteria prevented.*

*Accept: bacteria destroyed.*

*Accept: no living bacteria.*

**1**

(b)     Clear zone would be too large

**OR**

Clear zones would overlap/merge

**OR**

Could kill all bacteria (on the plate);

*Must convey idea of too large.*

**1**

(c)     1.      (Same) size;

*Accept: any measure of size e.g. thickness, area, diameter.*

*Ignore: ‘same shape’ as shape shown on the diagram.*

2.      (Same) material/absorbency;

3.      In solution for same time period;

*Ignore: reference to volume of disinfectant.*

**2 max**

(d)     Any number between 2.5 to 3.2 = **two** marks;;

*Allow* ***one*** *mark for an incorrect answer but shows method of calculating how many times more effective D is than B*

*e.g. 22 divided by 13/14*

*or 11 divided by 6.5/7*

*or 1.57/1.6/1.69/1.7.*

**2**

**[6]**

**M33.**(a)     1.      Equilibrium reached.

*Accept equilibrate*

2.      Allow for expansion / pressure change in apparatus;

3.      Allow respiration rate of seeds to stabilise.

*Ignore seeds acclimatise*

**3**

(b)     1.      Optimum temperature / temperature for normal growth of seeds;

2.      (Optimum temperature) for enzymes involved in respiration.

**2**

(c)     1.      Oxygen taken up / used by seeds;

2.      CO2 given out is absorbed by KOH (solution);

3.      Volume / pressure (in **B**) decreases.

**3**

(d)     0.975 / 0.98.

*If incorrect,*

*0.26 × 6 / or incorrect numbers divided by 1.6 for 1 mark*

**2**

**[10]**

**M34.**(a)     (To diagnose AIDS, need to look for / at)

1.      (AIDS-related) symptoms;

2.      Number of helper T cells.

*Neutral: ‘only detects HIV antibodies’ as given in the question stem*

**2**

(b)     1.      HIV antibody is not present;

*Accept HIV antibodies will not bind (to antigen)*

2.      (So) second antibody / enzyme will not bind / is not present.

**2**

(c)     1.      Children receive (HIV) antibodies from their mothers / maternal antibodies;

2.      (So) solution will always turn blue / will always test positive (before 18 months).

*Allow 1 mark for the suggestion that the child does not produce antibodies yet so test may be negative*

**2**

(d)     (Shows that)

1.      Only the enzyme / nothing else is causing a colour change;

2.      Washing is effective / all unbound antibody is washed away.

**2**

**[8]**

**M35.**(a)     Calculations made (from raw data) / raw data would have recorded initial and final masses.

**1**

(b)     Add 4.5 cm3 of (1.0 mol dm–3) solution to 25.5 cm3 (distilled) water.

*If incorrect, allow 1 mark for solution to water in a proportion of 0.15:0.85*

**2**

(c)     1.      Water potential of solution is less than / more negative than that of potato tissue;

*Allow Ψ as equivalent to water potential*

2.      Tissue loses water by osmosis.

**2**

(d)     1.      Plot a graph with concentration on the *x*-axis and percentage change in mass on the *y*-axis;

2.      Find concentration where curve crosses the *x*-axis / where percentage change is zero;

3.      Use (another) resource to find water potential of sucrose concentration (where curve crosses *x*-axis).

**3**

**[8]**

**E1.**In (a), 29% obtained both marks. The idea of induced fit was generally known but often poorly expressed. Some students wrote about the substrate having the same shape as the active site, rather than a complementary shape. A minority had the active site on the substrate.

The rate **at** 10 minutes in (b) was correctly calculated by 22% of students. These students drew a tangent to the curve at 10 minutes and used it to calculate rate. 19% of students obtained one mark after drawing an incorrect tangent, or making a mistake in their calculation from a correct tangent. The remainder simply divided the y axis number by the x axis number at 10 days and failed to score.

In (c), many students simply described the curve, rather than explaining. Some attempting an explanation incorrectly wrote about the enzyme being used up, or all its active sites being occupied. 13% obtained both marks for writing about a rapid rate at the start because there is lots of starch and the rate levelling off/falling to zero after 25/30 minutes as all the starch is used up. Some 43% obtained one mark for making one or other of these points.

Question (d) was based around skills that students were expected to have developed in required practical 3; that is to say the production and use of a calibration curve. The purpose of the required practicals is, generally, to allow students to practise and develop skills that can then be applied in many different settings. 21% of students obtained one mark, either for noting that the scientist would need solutions of maltose of known concentrations, or that a calibration curve would have concentration on the x axis and colorimeter reading on the y axis. About 12% obtained both of these marks. Only 5% then went on to (briefly) describe how the calibration curve would be used to determine the concentrations in the experiment.

**E2.**(a)     Most students were unable to provide appropriate units to compare the distribution of stomata on leaves. The units used varied from nanometres to metres and these were often measurements of length or volume rather than area. A significant number of students were under the mistaken impression that ‘per’ can be represented by a solidus.

(b)     Most students were able to obtain one mark in this question usually for explaining that light would be able to pass through a thin piece of tissue. Very few students obtained both marks by further explaining that a single/few layer(s) of cells was required for this to occur. Many students did not gain a second mark due to the use of imprecise terminology, others were clearly confused with references being made to ‘diffusion distance’, ‘water loss’ and ‘electrons’.

(c)     Almost 80% of students were able to obtain at least one of the two marks available. Both mark points were seen in relatively equal numbers. A common error was to refer to variation in the number of stomata on different leaves rather than in parts of the same leaf. There were also frequent references to anomalies, not always in the correct context.

(d)     The quality of the answers for this question was very disappointing. Consequently, 75% of students scored zero. Some students had not carefully read the question and described a range of xerophytic features of plants rather than those specifically related to leaves. Other students simply described two xerophytic features of leaves but did not provide explanations. However, most students did suggest two xerophytic features of leaves and gave explanations but these explanations lacked detail. Students often referred to ‘hairs trapping water’ rather than ‘water vapour’ and omitted any reference to water potential gradients. Another common response was ‘a waxy cuticle to reduce water loss’ which again lacks sufficient detail to gain credit. A common misconception was that small leaves reduce surface area to volume ratios rather than referring to needles or spines.

(e)     This question was problematic for many students, with only a third gaining any marks. The most frequently awarded mark point related to the use of water in photosynthesis. However, almost the same number of students suggested that water was produced in photosynthesis. Slightly fewer students mentioned the use of water to provide support/turgidity. There were far fewer references to the production of water during respiration or its use in hydrolysis. Again, weaker answers suggested that water is used in respiration or provided vague references to water being used for growth. A significant number of students referred to leakage of water from a potometer evidently having misinterpreted the context of the question.

**E3.**          (a)     This question separated candidates into those who had a general idea about electron transfer and those who appreciated the role of membranes in this process. A common error was to describe protons as moving into or out of the membrane, rather than across it. Although this question was largely based on factual recall, a significant proportion showed a lack of adequate preparation or clearly did not appreciate the level of detail expected.

(b)     (i)      A large proportion of candidates appeared not to understand what was meant by ‘isotonic’. Many believed the term to be associated with control of pH. Where answers were related to the control of water movement, many erroneously related osmotic damage to the cell rather than the organelles in question.

(ii)     Mitochondria were under investigation so glucose was not used as the respiratory substrate since it does not enter mitochondria. Glycolysis occurs in the cytoplasm. Surprisingly few candidates were able to explain this adequately.

(iii)     It was to be expected that rather more candidates would appreciate the role of oxygen as the terminal acceptor in the electron transfer chain than was the case. Many failed to make the necessary link suggesting that it was required for ATP production in some way.

**E4.**More sophisticated answers were required to gain credit here. Those students who wrote ‘food source’ rarely went on to state ‘food source for the plant-eating fish’. Similarly, those who wrote ‘shelter’ rarely went on to describe why this would be important for reducing stress or avoiding predators. Some gave acceptable alternative answers relating to plants providing a place for fish to lay eggs.

**E5.**          (a)     Although many candidates correctly identified the behaviour shown as a taxis, there were other responses including both kinesis and tropism. Those candidates who identified the type of behaviour correctly were generally able to provide the necessary evidence in part (ii). Those who failed to gain credit usually offered a general reason for their choice rather than select the specific evidence required from the information provided.

(b)     Poor examination technique often limited the marks that could be awarded. Many candidates ignored the responses of the termites in group A while others answered generally and offered a largely irrelevant interpretation of the responses of all three groups. Many of those who gained credit correctly recognised the importance of gravity as the stimulus. Few, however, linked detection of this stimulus to the antennae.

(c)     Although less able candidates failed to link the behaviour to the habitat of the termites, many were able to gain full credit for the idea that the winged insects would, thus, be able to leave the soil and found new colonies.

**E6.**          (a)     (i)      It could be concluded from the evidence in Figure 1 that fewer people visited site R because the mean value was lower than that for the other two sites. Although most candidates made reference to this, relatively few commented on the values of the standard deviations. All that was expected from the question about probability values was recognition that there was a probability of less than 5% that the difference was due to chance. It was clear in the answers to this part of the question that many candidates lack an understanding of the principles underlying statistical tests.

(b)     (i)      Candidates were more successful with part (b). Most appreciated that using only 10 quadrats was inappropriate because the number of species was still increasing.

(ii)     Similarly, using 25 was inappropriate since the curve on the graph had levelled out and the same result could be obtained using fewer quadrats.

(c)     Incubation at a high temperature would result in combustion and the loss of dry mass. Weaker candidates responded inappropriately to the reference to temperature and offered explanations based on enzyme denaturation.

(d)     Candidates who were successful with subsequent questions appeared to have spent some time interpreting the data first. Weaker candidates tended to plunge straight into questions, a strategy that resulted in limited credit. The ratio of dry biomass of animals to dry biomass of seaweeds is less than one because the animals feed on seaweeds. It is the loss of energy between trophic levels, due to respiration or as heat for example, that results in a ratio of less than one. Relatively few candidates were able to explain this.

(e)     The better candidates could show how the data in Figure 3 supported the view that a smaller number of larger seaweeds were found on frequently visited beaches. They appreciated that the site with most people (U) had the largest ratio for dry biomass of seaweeds to abundance of seaweeds, although they could not always justify this. The difficulty for many continued into the final part of this question, but better candidates could draw some conclusions. Rows one and four revealed that fewer larger animals were found where there was more human disturbance and credit was given where the data were used to support this idea. Row two showed that the number of plant species also fell where there was more disturbance.

**E7.**          (a)     (i)      Most candidates gained one mark for use of oxygen by the woodlouse. Candidates failing to gain any marks for this question often referred to ‘air being absorbed’. Many also gained a second mark by indicating that the carbon dioxide released by the woodlouse would be absorbed by the potassium hydroxide. Very few candidates obtained the final marking point by indicating that the pressure inside the tube would decrease. Answers such as ‘a vacuum is created’ were not credited.

(ii)     Over a third of candidates failed to gain any marks on this question. Reference to how far the bubble travelled and time was the only mark point for most candidates. Approximately one in five candidates obtained a second mark usually for referring to the radius or diameter of the capillary tubing. Very few candidates referred to the mass of the woodlouse. Candidates who realised that mass was one of the required measurements often referred to measuring the mass of oxygen, carbon dioxide or the apparatus.

(b)     As expected this proved to be a challenging question. Nevertheless, it was surprising that forty percent of candidates failed to obtain any marks. Considering the information provided it was disappointing to see some candidates describing details of photosynthesis. Although there were some excellent answers gaining maximum credit, these were a rarity with most candidates gaining a single mark. Usually, this mark was awarded for linking less ATP production to less or no proton movement. However, a number of candidates incorrectly referred to ATP being used to transport protons across membranes. Many candidates also mistakenly interpreted the fact that oxygen uptake remained constant as an indication that no oxygen was being used. Very few candidates linked the increase in heat production to the electron transport chain. Many interpreted this increase as an indication that respiration was occurring at a faster rate.

**E8.**          (a)     The majority of candidates completed the calculation successfully. A few failed to recognise that 18 marked and 20 unmarked birds produced a total of 38 birds trapped in the second sample. Collectively, there were various permutations of the three numbers with some candidates arriving at a population size that, on careful thought, could not have been right.

(b)     In the remaining parts of the question, better responses were seen from candidates who could apply their understanding of the limitations of mark-release-recapture with specific information.

(i)      In June, there is an increase in population size when young birds leave their nests to join the adult population. It was not appropriate to describe this as migration.

(ii)     In March, birds in territories would not mix within the population and sampling would result in capturing the same birds.

(c)     Recording the DNA base sequence of whales would be similar to marking the animals. If the base sequence were identified again, then it would be known that the same ‘marked’ animal had been recaptured.

Although many candidates clearly understood the technique of mark-release-recapture, a large number could not apply what they knew when presented with an unfamiliar context.

**E9.**(a)     The vast majority of candidates was able to give one correct environmental factor that the student should have kept constant during the investigation.

(b)     Answers to this question were generally disappointing with only a third of candidates appreciating that it was important to prevent air entering the shoot, xylem or potometer.

(c)     Approximately half the candidates obtained a mark for indicating that distance and time have to be measured. Very few candidates obtained a second mark by indicating that the radius, diameter or area of the capillary tube had to be measured.

(d)     Surprisingly, this proved the most difficult question on the paper. Seventy five percent of candidates scored zero with many candidates simply stating that not all the water is used in transpiration. Candidates obtaining one mark often referred to water being used in photosynthesis. Very few candidates obtained a second mark by indicating that water is used to provide support or that it may evaporate or ‘leak’ from the apparatus.

(e)     (i)      Most candidates simply suggested that the reservoir would allow water to be added. Fewer candidates gained the mark by linking this to moving the position of the bubble.

(ii)     Most candidates gained this mark by indicating that repeat measurements would enable the reliability of the results to be assessed.

**E10.**          (a)     (i)      Only the most able candidates gained this mark for suggesting that the blood vessels of healthy volunteers would not be affected by other factors or would be of normal size. Very few candidates noted that the blood vessels of healthy volunteers would function normally. Credit was given for valid ethical arguments, providing that they were qualified. However, a number of candidates failed to score through not relating their answers to the investigation. Weaker candidates tended to echo the need for ‘reliable results’ or ‘a fair test’.

(ii)     Nearly 65% of candidates were aware of the need to avoid bias or selection. However, some candidates thought the volunteers were divided randomly to ensure that both groups contained the same number of people, or the same number of males and females. As in part (a)(i), weaker candidates tended to confine their answers to 'reliable results' or 'a fair test'.

(b)     (i)      Most candidates noted that the control group should have been treated in the same way as the experimental group. However, it was only better candidates who stated that the control group should have been given chocolate with no flavenoids. The most common incorrect response was ‘do not give any dark chocolate’. Weaker candidates sometimes made vague references to using a placebo but this was not usually taken any further.

(ii)     Candidates were asked why it was important to have a control group in this investigation. Hence, this question tested the ability of candidates to apply their knowledge to an unfamiliar context. They were required to do more than define the term ‘control group’. For this reason, general answers such as that ‘results are not due to other factors’ and ‘results are due to the independent variable’ were not credited. Better candidates related their answers to this investigation. They were aware that a control group was used to ensure that the results obtained were due to the flavenoids or that they did not result from other substances in the chocolate. Many candidates were aware of the need to compare both groups. However, relatively few explained why this was necessary.

**E11.**          (a)     (i)      Candidates answered this question well, often referring to the optimum temperature of 30/31 °C. Weaker candidates did not use the graph and those who did not do so failed to score. Some candidates explained the effect of temperature on the rate of reaction rather than describing it.

(ii)     This part of the specification is well understood by candidates and many gained all three marks. A large number failed to answer the question asked and explained the shape of the curve between 20 and 30 °C. Although many of these candidates went on to score full marks, they wasted valuable time. It was pleasing to see that many candidates had understood the more difficult concept of more enzyme molecules being denatured as the temperature increased.

(b)     (i)      Most candidates correctly suggested using a buffer solution to maintain pH, but some answered in a different way by suggesting checking the pH at the end of the investigation using a pH meter or universal indicator. This also gained credit. Other indicators such as litmus would not give a precise enough measure of pH and so were not accepted. Surprisingly, common errors were to suggest keeping the temperature constant or sealing the plates.

(ii)     Most students suggested a temperature near the optimum to give a fast rate of reaction or a temperature lower than 30 °C to avoid denaturation. Both of these answers gained credit. A small number of candidates suggested a temperature but failed to give a reason.

(iii)     Most candidates gained credit here, but a minority were uncertain as to whether high or low pH was acidic. Weaker candidates did not make the link between the size of the cleared area and the activity of the enzyme.

**E12.**          (a)     Although a considerable number of candidates gained credit for their answers to this part of the question, others offered inappropriate suggestions. Many of these were yet again centred on the converse and attempted to explain why they did not measure the minimum diameter.

(b)     There was evidence from the answers to part (i) that many candidates still fail to absorb material presented in the stem of a question or look critically at data in tables and graphs. Thus, although most appreciated that shrimps that lived in caves had smaller eyes and longer antennae than those that lived in the open, they were unable to point out either that the antennae were responsible for detecting touch or that these data only referred to shrimps. More limited candidates often suggested that shrimps either had eyes or sense organs. Those candidates who avoided explaining standard deviation in terms of range, generally gained at least one mark for part (ii). Better candidates were also aware that overlap in the values of standard deviation was important in indicating whether differences were attributable to chance or were significant.

(c)     In part (i), most candidates made an appropriate qualitative statement about the body lengths of the shrimps concerned but few supported this with data from the graph. Some appeared distracted by antennal length and failed to identify the thrust of the question. Part (ii) was generally well answered.

(d)     Most candidates appeared to have understood the information in the graph but could not always explain this with sufficient clarity to gain credit. Thus, although an answer relating to cave shrimps and ocean shrimps (interpreted as shrimps living in open streams) could be awarded credit, one that merely referred to shrimps in streams could not. There were also many sweeping statements such as that “the percentage of shrimps was higher in the open for all alleles”. This was clearly not correct. More credit might have been awarded had candidates based their wording more carefully on that supplied in the column headings in the table.

(e)     One of the key phrases in this question was “Use your knowledge of the founder effect”. This should have indicated that candidates were required to apply this concept to the example provided in the question. A significant number failed to do this and opted instead to discuss the difference in percentages in terms of either natural selection or genetic bottlenecks. Such approaches rarely gained credit. Others offered extremely general explanations that made no reference either to shrimps or to allele L. These accounts often incorporated volcanic eruptions and hunting to extinction. Answers were further marred by imprecise language with the term “species” used in a variety of ways that had an adverse effect on the sense of the argument presented. Some candidates again turned the question round and attempted unsuccessfully to use their knowledge of the founder effect to explain the percentage of shrimps with the allele L in the open.

(f)      Candidates who answered this question successfully either suggested breeding cave shrimps with those living in the open to see if fertile offspring were produced, or looking at whether courtship behaviour led to successful mating. Although both of these approaches were acceptable, those based on DNA hybridisation and protein analysis were not. Those candidates who chose to discuss crossing shrimps often suggested procedures that would not have guaranteed the relevant parentage. Attempts were made to add detail and there were some valid comments about repeats and carrying out reciprocal crosses. However, there was much discussion about the ethics of experimental work and the perceived cruelty of such experiments that could not be given credit.

**E13.**          (a)     60% of candidates gained one mark for the idea that water on the outside of the cylinders would affect the mass, or that only the water taken up or lost should be measured. Only the very best candidates were aware that the amount of water on the cylinders would vary. A common response by weaker candidates was that water on the outside of the cylinders would allow further osmosis before reweighing. This was not credited. Vague responses that referred to greater reliability or accuracy were common.

(b)     One third of candidates gave the correct volumes of 4cm3 and 16cm3.

(c)     It was encouraging to note that candidates did better on this question than they did on a comparable question in January 2010. One third of candidates gained full credit. Many were aware that expressing a change as a percentage allows a comparison to be made. However, it was usually only better candidates who wrote that the cylinders would have different starting masses. The stem of the question made it clear that both the starting and final masses of the cylinders were recorded. It therefore had to be clear to which of these the candidates was referring. Weaker candidates often referred to ‘different sizes’ or ‘different masses’. These responses were not credited.

(d)     Two thirds of candidates gained one mark for the idea that anomalies could be identified. However, some thought that repeats prevented anomalies from occurring or being recorded. It was only the very able candidates who wrote that repeats allow a more reliable mean to be calculated. Taking additional readings does not necessarily allow results to be closer to the true value. Hence, references to ‘a more accurate mean’ were not credited. Weaker candidates often referred to ‘the results’ being more reliable or more accurate without qualifying their answers.

(e)     70% of candidates correctly read off the intercept on the *x*-axis at 0.35 mol dm–3.

**E14.**          (a)     This was a straightforward question with over ninety percent of candidates gaining both marks and very few scoring zero.

(b)     A third of the candidates gained this mark for clearly indicating that measuring water loss in milligrams would improve precision or accuracy. Incorrect responses often mentioned reliability, anomalous results, or calculating a mean.

(c)     Some answers were limited to descriptions of the graph and scored zero, or referred in general terms to transpiration for one mark. Candidates scoring three marks often provided a clear, detailed explanation of the results including reference to changing water potential gradients and the opening and closing of stomata. A significant number of candidates also realised that water was not replaced in the leaves as they were detached.

(d)     Most candidates gained one mark for indicating that there would be less transpiration or evaporation. Far fewer candidates, however, suggested that the grease had covered the stomata or had increased the diffusion pathway. Many candidates failed to get this mark as they simply stated that the grease provided a waterproof layer.

**E15.**          (a)     Most candidates were well prepared for this question and were able to differentiate between active transport and facilitated diffusion with many gaining both marks. Some candidates were unclear when referring to concentration gradient. Phrases such as ‘along the gradient’ or ‘across the gradient’ were not accepted. The specification terms ‘carrier protein’ and ‘channel protein’ were often not used.

(b)     (i)      The question asked why a control group was used „in this trial’. Candidates needed to apply their knowledge to an unfamiliar context and were required to do more than simply define the term. It was, therefore, not enough to say ‘to allow comparison’.

(ii)     This question was well answered with many candidates gaining both marks. A large number referred to a placebo tablet being used, although this term was not required. Some candidates failed to gain the first marking point as they stated that no drug would be given without appreciating that a tablet would still need to be administered. Most explained that both groups should be treated in the same way.

(c)     This question required the candidates to look carefully at the graph and describe it. Many incorrectly stated or implied that the volume of acid secreted per hour would decrease for 4 hours, failing to notice that the treatment started 1 hour after volumes were recorded. More able candidates realised that the acid secretion would decrease for 3 hours, or from 1 – 4 hours.

**E16.**          (a)     In part (i), most students gained the second marking point. Very few mentioned alleles and so the first marking point was rarely awarded.

In part (ii), most students gained the first marking point and around half gained the second. There were a lot of references to efficiency of conversion and to variables not being controlled.

(b)     Most students gained this mark for part (i), although a surprising number thought the peak was at 30°C. Some only described either an increase or a decrease with temperature. Others described the increase up to 20°C and then a decrease from 30-35°C. A few thought that as temperature increases, growth rate decreases.

Marking point 1 for part (ii) was given by a majority of students, around half of whom gained credit for the second point, with answers being expressed in a variety of ways.

(c)     In part (i), most students gained the first mark; relatively few gained either the second or third mark, usually by stating that growth was unlikely to increase beyond 35°C or that it would have been a waste of time to investigate higher temperatures. A large number of students were under the apparent impression that as soon as environmental temperature exceeded 35°C all of the pigs’ enzymes would immediately denature.

A significant minority of students did not gain marks in part (ii) because they failed to make comparative statements. However, most gained the first marking point. Around a quarter gained the second. The third was rarely seen. A significant minority of students wrote about the effect of the external temperature on the pigs' enzymes in terms of collisions and enzyme-substrate complex formation.

(d)     The label on the y-axis gave many students the reference to the control that they needed for the first marking point and most used the error bars in their discussion, but many failed to gain marks by referring to the smaller error bar on food **B** rather than identifying the overlap between **A** and **B**. All of the marking points were seen, but it was very rare for any one candiate to have looked beyond the first idea that caught their attention and develop enough points to gain all four marks. A significant minority of answers gave generic ‘How Science Works’ responses involving repeats, validity, correlation not proving casuation and reliability, failing to contextualise their answers.

**E17.**(a)     This question produced a good spread of marks. Most students referred to haemoglobin combining with oxygen in red blood cells and appreciated that loading took place in the lungs. Some students then described the unloading of oxygen at respiring tissues and these students often linked this to the increase in carbon dioxide. Generally, only better students referred to high and low partial pressures of oxygen and gained maximum marks. A significant minority of responses ignored loading and unloading of oxygen and described the passage of oxygenated blood through the circulatory system.

(b)     Almost half the students failed to gain a mark as they often simply referred to it being a 'fair test' without an explanation. Most answers gaining credit mentioned enzymes and better students linked this to respiration to gain two marks. Answers relating to the temperature affecting the amount of dissolved oxygen were fairly infrequent as were references to enabling 'comparisons' between the larvae of both species.

(c)     Most students appreciated that the mean rate of oxygen uptake increased and then levelled out with an increase in oxygen concentration in the water. However, only better students specifically referred to where oxygen uptake levelled out. Students gaining zero marks often stated that there was a positive correlation between the variables.

(d)     Many students noted, for one mark, that Chironomus longistylus has a higher oxygen uptake at lower concentrations of oxygen. However, less than 25% of students used the data to support their observation and gain a second mark.

(e)     (i)       Almost 80% of students gained this mark, often by stating that more oxygen is lost via the gills in Australian lungfish than in African lungfish.

(ii)     Most students were aware that more exchange is via the lungs in African lungfish. However, far fewer students gained a second mark by mentioning that gills would not function in air.

**E18.**          (a)      Many students knew exactly how to investigate the distribution of marram grass across a sand dune and gained three marks. If one point was missing, it tended to be marking point 2, because the quadrats were not placed regularly. Many answers referred to random sampling and using two tapes at right angles and co-ordinates generated from a calculator’s random number generator. These answers were not appropriate.

(b)     Some excellent answers were seen which explained both points and gave several of the options for the second marking point. Many students gained the second marking point only, often giving two aspects of that point, usually less hostile and adding nutrients. Improved water retention was less commonly stated. Uncredited responses often described succession and the entry of new species to reach a climax community without explaining the role of marram grass in this process. A few students merely described what a pioneer species is or described the way the features of marram grass enable it to survive in harsh conditions.

**E19.**(a)      Many students gave a full definition, including location and time. A surprising number of students gave vague responses relating to a group of organisms, a collection of organisms or a number of organisms. Some only referred to animals or just several different species or all the organisms of one species, without the important idea of the community including all the organisms in the location.

(b)     In their answers to part (i), there were many very clear accounts that scored all four marking points. Quite a few students forgot to mention releasing the fish or failed to describe either a way of marking the fish or that the method should not harm the fish or make them more visible to predators. References to the percentage of marked fish in the second sample were often seen. The equation was sometimes incorrect with the total number caught as the denominator.

The vast majority of students gained the mark for part (ii), clearly understanding that the population would be increasing. Other correct answers related to behaviour during the breeding season that would result in an unrepresentative number of fish being caught. Some responses failed to gain credit because they did not clearly relate to behaviour associated with breeding.

(c)     Many students correctly linked the shape of the mouth to the different food types exploited. However, while competition was sometimes mentioned, only the better students were able to link this to reducing competition between species, thereby showing an understanding of the significance of the niche. A significant number tried to explain how different mouth shapes arise by natural selection.

**E20.**(a)     (i)      Over 80% of students had little difficulty obtaining both marks in this question. Students who obtained one mark often provided two examples of lifestyles or referred to age which was excluded in the stem of the question.

(ii)     This was also well answered with over 70% of students gaining both marks. Most students referred to the large sample size and that the study took place over a long period of time. Some weaker students incorrectly answered the question in terms of additional features which may have been desirable in this investigation.

(b)     Approximately half the students obtained both marks for this calculation. 20% of students obtained a single mark for their method of calculation or provided an answer of 210 rather than 209 / 209.1.

(c)     Most students made the link between age and the risk of getting cancer. Answers which linked age to caffeine consumption were not credited.

(d)     The majority of students obtained at least two marking points often for stating that a correlation does not mean a causal relationship and for mentioning that tea /coffee contains other substances. All the other marking points were seen by examiners but surprisingly few responses included a reference to the lack of a control group in this investigation.

(e)     (i)      The vast majority of students gained at least one mark by stating that the control group would be treated in exactly the same way as the experimental group. Over 50% of these students gained a second mark by mentioning that the control group should not have caffeine. Answers which were limited to using a placebo without mentioning lack of caffeine were not credited.

(ii)      Almost two thirds of students gained this mark often by referring to different rates of absorption, different sources of caffeine or to people having different blood volumes.

(iii)     Slightly less than half the students obtained this mark usually by referring to a lack of oxygen supplied to the cancer cells or to the spread of cancer cells being reduced.

**E21.**          (a)     Four out of five students were able to name ribulose bisphosphate as the substance which combines with carbon dioxide in a chloroplast.

(b)     The formation of ATP and reduced NADP in the grana was well known by many students. A significant number did not state that the NADP was reduced and some referred to reduced NAD. Others knew that the light-dependent reaction occurred in the grana but did not identify the products needed in the light-independent reaction or only identified one of the two. Others only stated that the stroma is where the light-independent reaction takes place which fixes carbon dioxide. Some thought that the grana have no effect on the uptake of carbon dioxide or that the light-dependent reaction occurs in the stroma.

(c)     This proved more demanding with only one in four students gaining both marks. Most students did appreciate that the lack of light would prevent the light-dependent reaction from taking place or named the products which could no longer be produced from this process. However, they often did not use this information to predict the uptake of radioactively labelled carbon dioxide if tube **A** were placed in the dark. A few students thought there would be ‘no difference’ to the uptake of carbon dioxide in the dark as the light-independent reaction does not use light. A small number of students thought that there would be more respiration in the dark leading to an increase in carbon dioxide in tube **A**.

(d)     Despite the question asking students to use their knowledge of the light-independent reaction, a significant number of students only referred to the lack of the products of the light-dependent reaction resulting in a lack of RuBP without any details of the pathway of its production. Many students did appreciate that ATP and reduced NADP were involved in reducing glycerate 3-phosphate but not all of them named triose phosphate as the product to gain a mark. Relatively few students obtained the second marking point by outlining that RuBP is formed from triose phosphate.

(e)     Less than a third of students obtained both marks in this question. However most gained at least one mark often by linking electron transfer to the production of ATP. The fact that electron transfer is required for the reduction of NADP was less well known. The reference to electron transfer in the question resulted in some weaker students providing details about chemiosmosis in respiration or relating to reduced NAD.

**E22.**(a)     Students were provided with “kinetic energy” as a starting point for their answers to this question and therefore should not have expected credit merely for stating that it decreased. They were expected to go beyond this and link the decrease in kinetic energy to the slower speed of molecular movement and, if they approached the question from an enzyme standpoint, fewer collisions between enzymes and substrates. In general, there was a clear understanding of principles but responses often lacked the necessary detail to secure full credit.

(b)     (i)      While it was widely appreciated that the use of ratios allowed comparisons to be made, fewer students could explain why their use was important in the context of this investigation. The key feature was that it took into account differences in the initial amount of fungus, not just the amount of fungus.

(ii)     The majority of students used the model provided and expressed the results of their calculations appropriately.

(c)     It was again clear from the responses to this question that many of the less able students experienced difficulties with a question that required explanation. It was apparent to the moderating team that while most understood the relatively simple idea underpinning the question only the better students were able to explain this logically and unambiguously.

**E23.**          (a)     Weaker students typically gave vague answers such as ‘light would affect the results’, ‘to control a variable’ or ‘roots grow underground so it must be kept dark’. A minority thought that roots are positively phototropic or that light would allow photosynthesis to occur.

(b)     Just under half of students appreciated that the results indicated the root tip responds to gravity or that IAA is produced in the root tip. Weaker students usually gave vague answers that did not refer to the root tip.

(c)     (i)      Half of the students answering this question scored at least one mark for the idea that the upper side of the root grew faster than the lower side. Weaker students often failed to appreciate that both sides of the root grew and therefore did not give a comparative statement. The specification content for BIOL5 requires that students should understand ‘the role of IAA in controlling tropisms in flowering plants’. Despite this, it was clear that some students had no knowledge of geotropism. Some answers referred to ‘weaker’ and ‘stronger’ gravity, or that gravity only acts on the lower side of the root. Similarly, it was very clear that some students did not know that IAA inhibits growth in roots. Students who made these errors could still gain one mark for the idea that the upper side of the root grew faster than the lower side. Indeed, this mark was frequently awarded to students who located IAA on the upper side of the root and thought that IAA stimulated growth in roots.

(ii)     Over one third of students were aware that removing part of the root tip would result in less IAA being produced. However, it was only the very best students who linked this to faster growth or less inhibition of the lower side of the root.

**E24.**          (a)      A significant number of students failed to explain adequately why both experiments were carried out at the same temperature. Their responses were often limited to having a ‘fair test’ or controlling a variable. Students who provided more details often gained a mark for mentioning that temperature affects enzyme-controlled reactions. Better students specifically referred to respiration and obtained the second mark point.

(b)     (i)      This question provided a good spread of marks. The most common scoring point was the absorption of carbon dioxide by potassium hydroxide. Many students gained a second mark for the uptake of oxygen by the seeds. Better students obtained maximum marks by stating that a decrease in volume or pressure in the flask would cause the level of the coloured liquid to go down in the right-hand side of the manometer tube. However, a significant number of students failed to gain this mark as they only referred to a change in pressure or stated that a vacuum was produced. Some students suggested that photosynthesis was taking place with the seeds absorbing carbon dioxide and producing oxygen.

(ii)     Rather surprisingly relatively few students provided the correct answer of 4. The most common incorrect answer was 5, although a full range of numerical values from 0 to 15 was noted by examiners.

(c)      Approximately one in four students gained both marks. These students often clearly explained that no oxygen would be used by the seeds and, as any carbon dioxide produced would be absorbed by the potassium hydroxide, the level of liquid would not change. A third of students gained one mark often for stating that no oxygen uptake would occur. Some students negated this mark point by suggesting that carbon dioxide is not produced during anaerobic respiration. A minority of students suggested ethanol would affect the level of coloured liquid in the tube.

**E25.**          (a)     The Benedict’s test for reducing sugars was well known with most students gaining all three marks. The main problem here was that many students failed to heat the solution, either by not mentioning heating at all or simply saying ‘put it in a water bath’ without specifying a temperature - water baths can be at any set temperature. There was a significant number who confused the tests for reducing and non-reducing sugars and a small number who described other biochemical tests.

(b)     (i)       It was encouraging to see that the best students were able to apply their knowledge of several different parts of the unit and explain their answers well. These answers were often concise, explaining that more maltose would be produced, lowering the water potential so that water entered by osmosis.

There were many confused answers, however, and it was evident that some students were unsure as to whether pH 2 was acidic or alkaline. Most understood that amylase would hydrolyse the starch into maltose but then went on to write at length about the effect of pH on the rate of enzyme action.

(ii)     Most students gained this mark, realising that you need to look at a range of pH values to be able to conclude what the optimum pH is, but some obviously thought that optimum simply meant the best of those considered. There was a surprising number of students who inexplicably referred to the optimum temperature.

**E26.**It appeared that some students had not used a potometer. The investigative and practical skills section of the specification for this unit clearly states that students require specific knowledge of the use of a potometer to measure the rate of water uptake. It also makes clear that students can be tested on this in the examination.

(a)     Many students were aware that opening the tap would return the air bubble to the start. Students who appeared unfamiliar with a potometer usually made incorrect guesses from the diagram, e.g. ‘add water to the reservoir’, ‘remove the plant’ or ‘remove the bung’.

(b)     60% of students gained at least one mark. Better responses usually went beyond ensuring that the apparatus was airtight. The question asked for specific precautions that should have been taken when *setting* up the potometer. Despite this, weaker responses typically named factors that should be kept constant.

(c)     Given that this question has been asked in a previous series, it is disappointing that over 60% of students scored zero. Better responses showed appreciation that water is used for support and photosynthesis and produced during respiration. However, weaker responses seemed to focus on the word ‘transpiration’ in the question stem. Consequently, references to the opening and closing of stomata, effects of environmental factors and not all water being used in transpiration were widespread. Similarly, some students thought that water is used in respiration, or produced during photosynthesis.

(d)     This proved to be an excellent discriminator. Just under half of students scored at least two marks. This was usually for appreciating that removing more leaves meant fewer stomata, less transpiration and less tension. Unfortunately, weaker responses often did no more than describe the relationship between the number of leaves removed and the rate of transpiration. Some students had difficulty in applying their knowledge to an unfamiliar context. They wrote all they knew about cohesion-tension, without linking this directly to the data in the table.

**E27.**Most students identified that chlorophyll b could absorb some of the light that passes through leaves. Many then failed to identify accurately the cross-over ranges of light available and light absorbed to gain the second mark.

**E28.**(a)    Almost three out of four students appreciated that the layer of oil prevented the entry of oxygen. Answers which simply stated that this layer prevented aerobic respiration taking place were not credited as this was not considered to be a full explanation.

(b)    (i)      Only a third of students provided a fully correct answer for two marks. Approximately 20% of students gained one mark for carrying out a partially correct calculation, which did not include the step of dividing by five to obtain the rate per gram. Other errors included adding together the four volumes of gas at 10, 20, 30 and 40 minutes before the total was divided by 40, or students noted the volume of gas of 0.3 cm3 produced at 10 minutes and subtracted this from the 3.1 cm3 produced after 40 minutes, before any division was attempted.

(ii)     The majority of students gained this mark by stating that glucose was decreasing in the flask. The increase in ethanol killing the yeast cells was also often stated. Incorrect responses usually referred to lack of oxygen or, less often, the yeast being used up.

(iii)    Approximately one out of every three students gained both marks by stating that the oxygen used was equal to the carbon dioxide produced and that the volume in the syringe would remain the same. However, not all students explained why the volume would remain the same and were awarded one mark. Invariably, students who stated that the volume would change, by either increasing or decreasing, scored zero.

(c)     Many students gained one mark for stating that only glycolysis would occur in the absence of oxygen. Three out of every five students then explained the specific role of oxygen in the electron transport system, or described where ATP is produced in aerobic respiration. Some responses gave a full, detailed account of the Krebs cycle, electron transport chain and how ATP is produced. These answers often required additional pages.

**E29.**The examiners noted that many students appeared not to have read the main stem of the question carefully.

(a)     Quite a large number wrote about amylase in yoghurt, rather than an inhibitor of amylase. About two thirds identified that **Group A** allowed the effect of the inhibitor to be seen. Very few noted that it also allowed the effect of yoghurt on its own to be seen. Quite a large number simply stated that the group ‘allowed for comparison’.

(b)     60% identified that different foods might affect glucose intake. Very few went on to identify that they could also contain different amounts of starch, the substrate of amylase. Quite a few simply wrote about ‘removing a variable’.

(c)     A third of students obtained both marks. These students displayed a clear understanding of the digestion of starch, including the enzymes involved, the products produced and the impact of the inhibitor. About 40% failed to score, with the commonest error being a statement that starch is ‘broken down’ directly into glucose.

(d)     The examiners had identified six different reasons why the results might not support the use of the inhibitor, based on the context of this question. Many students resorted to rote How Science Works answers about correlation not causing causation, or bias. Nearly half of students failed to score.

**E30.**(a)     It was vital that students used the information that was provided in the resource accurately rather than giving generalised methods of making data reliable. Mark points 1 and 2 could be awarded when given in a single statement such as, ‘several fields of view were selected at random’. In mark point 3 ‘species’ was essential, ‘same breed’ is not equivalent. Mark point 5 needed to be specific to the resource, i.e. that at least 8 animals were used in each group. General statements about each group having lots / large number of hamsters were insufficient.

(b)     (i)      Most students successfully carried out this calculation.

(ii)     Mark point 1 was most commonly seen. In this instance, ‘The calculation used an average’ was acceptable as equivalent to mean, as it demonstrates the correct understanding.

(c)     (i)      The occasional student suggested that this investigation was unethical as the hamsters would be in pain or stressed but the vast majority realised hamsters would be killed.

(ii)     Students encountered many problems with this question. Many only discussed changes ‘as the hamsters got older / younger’, rather than using the specific age groups. Some only discussed whether there was a change, or what the change was, rather than discussing the significance of this difference. Many students seemed unaware that it is not the ‘results’ that are deemed significant or not but the ‘differences between the results’. It was surprising at A2 that not more students achieved mark points 5 and 6. It was expected that students who had calculated standard error and 95% confidence limits in Stage 2 of this ISA would realise that standard deviation is insufficient to determine significance.

**E31.**(a)     Fewer than fifty percent of students correctly referred to oxygen production and time. Many simply referred to oxygen production or uptake of carbon dioxide. A number of students mentioned the mass / volume of the algal cells and suggested measuring the rate of oxygen production per unit mass of cells per unit time.

(b)     Two thirds of students were able to suggest two correct factors and almost every student obtained at least one mark usually for light intensity or carbon dioxide concentration. Despite the rubric stating ‘other than temperature’, a significant minority gave temperature as one of the factors. Common incorrect responses included water concentration, humidity and wavelength of light.

(c)     Approximately half the students obtained both marks explaining that the increase in pH was due to carbon dioxide being absorbed and used in photosynthesis. However, other students did not state whether the pH increased or decreased when carbon dioxide was removed from the solution, even though they correctly described the solution becoming more alkaline or less acidic. A decrease in pH sometimes became an increase by the end of an answer. Weaker responses often confused carbon dioxide with oxygen and respiration with photosynthesis. These students often suggested that carbon dioxide or oxygen was alkaline.

(d)     Most students obtained at least one mark usually for outlining the role of light energy in the light-dependent reaction. Fewer students obtained the first mark point as they suggested no light was absorbed rather than less absorption of light. Nevertheless, almost forty percent of students gained both marks by linking less absorption to a decrease in the light-dependent reaction or by suggesting that the wavelengths reflected represented green light. Incorrect responses often referred to limiting factors such as temperature or carbon dioxide.

**E32.**(a)     Approximately two thirds of students correctly explained that the clear zone was due to the disinfectant killing the bacteria. Answers which only referred to the growth of bacteria being prevented were not credited as the stem of the question outlined that a culture of bacteria had already been grown on the agar.

(b)     Slightly over half the students gained this mark. Most referred to the clear zones being too large or merging. A significant minority did refer to all the bacteria being killed. Students failing to gain credit often provided vague responses relating to the clear zones, concentrations of disinfectants, enzyme denaturation or safety concerns.

(c)     Almost 90% of students obtained at least one mark, usually related to controlling the size of the paper disc. Approximately 40% of students gained the second mark for outlining that the discs should be soaked in each disinfectant for the same time period. A common response was to suggest that the same volume of each disinfectant should be used but as the information stated that the discs were soaked, this was not credited.

(d)     30% of students obtained both marks for his question. A similar percentage obtained a single mark for an incorrect answer but a valid method of calculating how many times more effective disinfectant D was than disinfectant B. Most students did this by dividing the diameters or the radii of the clear zones.