Biological washing powders contain enzymes which hydrolyse substances that cause stains on clothes.

A manufacturer tested the ability of two types of the same brand of washing powder to remove different food substances that stain clothes.

- Type A contained an enzyme.
- Type B was identical to A except it did not contain the enzyme.

Figure 1 shows the results.
A scientist worked for a company that wanted to develop a biological washing powder that was effective over a range of temperatures. He investigated the effect of temperature on the rates of the reaction catalysed by two enzymes, P and S used in biological washing powders.

**Figure 2** shows his results.

![Graph of Enzyme P and Enzyme S](image)

(a) Many of the substances causing the food stains are large, insoluble proteins. Suggest how a biological washing powder removes this type of stain.

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(2)
(b) The manufacturer of type A and type B washing powder claimed that these results showed that biological washing powders are better at removing stains from clothes.

Use the information in Figure 1 to evaluate this claim.

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(d) Biological washing powders often contain a number of different enzymes. This enables them to remove a wider range of stains from clothes. Explain why a number of enzymes are required to remove a wider range of stains.

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(Total 12 marks)

(a) DNA helicase is important in DNA replication. Explain why.

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(2)
Scientists investigating DNA replication grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen ($^{15}$N). They obtained DNA from a sample of these bacteria.

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen ($^{14}$N). The bacteria were allowed to grow and divide twice. After each division, DNA was obtained from a sample of bacteria.

The DNA from each sample of bacteria was suspended in a solution in separate tubes. These were spun in a centrifuge at the same speed and for the same time. The diagram shows the scientists’ results.

![Diagram showing DNA replication results](image-url)
(b) The table shows the types of DNA molecule that could be present in samples 1 to 3. Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

<table>
<thead>
<tr>
<th>Type(s) of DNA molecule present in each sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

(3)

(c) Cytarabine is a drug used to treat certain cancers. It prevents DNA replication. The diagram shows the structures of cytarabine and the DNA base cytosine.

(i) Use information in the diagram to suggest how cytarabine prevents DNA replication.

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Cytarabine has a greater effect on cancer cells than on healthy cells. Explain why.

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).

<table>
<thead>
<tr>
<th>Hamster age group</th>
<th>Number of hamsters in group</th>
<th>Mean number of capillaries associated with each type of muscle fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Slow fibres (± SD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fast fibres (± SD)</td>
</tr>
<tr>
<td>Young</td>
<td>9</td>
<td>3.4 (±0.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0 (±0.8)</td>
</tr>
<tr>
<td>Adult</td>
<td>10</td>
<td>4.7 (±0.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.3 (±0.4)</td>
</tr>
<tr>
<td>Old</td>
<td>8</td>
<td>4.6 (±0.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8 (±0.6)</td>
</tr>
</tbody>
</table>
(a) Give **four** precautions that the researchers took to make their calculations of mean number of capillaries per fibre reliable.

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

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(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 = ..........................................................

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

Evaluate this conclusion.

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(Total 12 marks)
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 cm$^3$ 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.

<table>
<thead>
<tr>
<th>Concentration of sucrose solution / mol dm$^{-3}$</th>
<th>Percentage change in mass of potato tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>+4.7</td>
</tr>
<tr>
<td>0.20</td>
<td>+4.1</td>
</tr>
<tr>
<td>0.25</td>
<td>+3.0</td>
</tr>
<tr>
<td>0.30</td>
<td>+1.9</td>
</tr>
<tr>
<td>0.35</td>
<td>−0.9</td>
</tr>
<tr>
<td>0.40</td>
<td>−3.8</td>
</tr>
</tbody>
</table>

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

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(b) Describe how you would use a 1.0 mol dm$^{-3}$ solution of sucrose to produce 30 cm$^3$ of a 0.15 mol dm$^{-3}$ solution of sucrose.

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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)
Metastatic melanoma (MM) is a type of skin cancer. It is caused by a faulty receptor protein in cell-surface membranes. There have been no very effective treatments for this cancer.

Dacarbazine is a drug that has been used to treat MM because it appears to increase survival time for some people with MM.

Doctors investigated the use of a new drug, called ipilimumab, to treat MM. They compared the median survival time (ST) for two groups of patients treated for MM:

- a control group of patients who had been treated with dacarbazine
- a group of patients who had been treated with dacarbazine and ipilimumab.

The ST is how long a patient lives after diagnosis.

The doctors also recorded the percentage of patients showing a significant reduction in tumours with each treatment.

The total number of patients in the investigation was 502.

The table below shows the doctors’ results.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Median survival time (ST) / months</th>
<th>Percentage of patients showing significant reduction in tumours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dacarbazine</td>
<td>9.1</td>
<td>10.3</td>
</tr>
<tr>
<td>Dacarbazine and ipilimumab</td>
<td>11.2</td>
<td>15.2</td>
</tr>
</tbody>
</table>

(a) The doctors compared median survival times for patients in each group.

How would you find the median survival time for a group of patients?

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(b) In many trials of new drugs, a control group of patients is given a placebo that does not contain any drug.

The control group in this investigation had been treated with dacarbazine. Suggest why they had not been given a placebo.

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(1)

(2)
(c) A journalist who read this investigation concluded that ipilimumab improved the treatment of MM.

Do the data in the table support this conclusion? Give reasons for your answer.

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(4)

(d) MM is caused by a faulty receptor protein in cell-surface membranes. Cells in MM tumours can be destroyed by the immune system.

Suggest why they can be destroyed by the immune system.

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(3)

(Total 10 marks)
(a) Describe how water is moved through a plant according to the *cohesion-tension* hypothesis.

............................................................................................................................................... (4) 

(b) The mass of water lost from a plant was investigated. The same plant was used in every treatment and the plant was subjected to identical environmental conditions. In some treatments, the leaves were coated with a type of grease. This grease provides a waterproof barrier. The results of the investigation are given in the table.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mass lost in 5 days / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>No grease applied</td>
<td>10.0</td>
</tr>
<tr>
<td>Grease applied only to the upper surface of every leaf</td>
<td>8.7</td>
</tr>
<tr>
<td>Grease applied to both surfaces of every leaf</td>
<td>0.1</td>
</tr>
</tbody>
</table>

(i) What is the advantage of using the same plant in every treatment?
............................................................................................................................................... (1)

(ii) Why was it important to keep the environmental conditions constant?
............................................................................................................................................... (1)

(iii) What is the evidence that the grease provides a waterproof barrier?
............................................................................................................................................... (1)
(c)  
(i) Calculate the mass of water lost in 5 days through the upper surface of the leaves.

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

(1)

(ii) Use your knowledge of leaf structure to explain why less water is lost through the upper surface of leaves than is lost through the lower surface.

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(2)
(Total 10 marks)

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**

Jelly containing blue substance

Colourless zone

Fungus

**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.
(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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(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.

\[
\text{Ratio} = ....................................................
\]

(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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(Total 8 marks)
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.

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

Key
- Shrimps from streams in caves
- Shrimps from streams in the open
(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**

<table>
<thead>
<tr>
<th>Gene</th>
<th>Allele</th>
<th>Percentage of shrimps with this allele in steam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inside a cave</td>
</tr>
<tr>
<td>PGI</td>
<td>A</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>98.2</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>0.0</td>
</tr>
<tr>
<td>ACO2</td>
<td>J</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>100.0</td>
</tr>
</tbody>
</table>

(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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(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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(1)

(3)
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)
The drawings show two dogwhelks taken from two different populations. Dogwhelk A came from a sheltered shore and dogwhelk B from a shore exposed to heavy wave action. The dogwhelks attach themselves to rocks with a muscular foot which comes out through the aperture. The shell length : aperture length ratios (L/A) were calculated. The mean and standard deviation for each population are shown under the drawings.

\[
\begin{align*}
\text{mean L/A ratio} & = 1.91 \\
\text{standard deviation} & = 0.19 \\
\text{mean L/A ratio} & = 1.78 \\
\text{standard deviation} & = 0.10
\end{align*}
\]

(a) Describe how you would collect a random sample of each population.

(b) What do the standard deviations tell you about the two populations of dogwhelks?
(c) Suggest how the effect of wave action on the two populations of dogwhelks could result in differences between

(i) the mean L/A ratios;
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................

(ii) the standard deviations.
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................

(4)
(Total 9 marks)
Mark schemes

(a) 1. Enzyme hydrolyses / breaks down protein to amino acids;
    2. Products are soluble / can be washed away;

(b) Arguments for biological washing powder:
    3 max if only arguments against biological washing powder are referred to

1. More effective with all stains;
   Accept different ways of expressing ‘effective’ e.g. higher % of stain removed

2. Greater improvement with salad dressing / chocolate milkshake / chocolate pudding;

Arguments against biological washing powder:

3. Little / less improvement with raspberry sorbet / raspberry smoothie;

4. Only tested 5 / a small number of stains;

5. Only chose stains that would work / didn’t select stains that wouldn’t work;

6. Only included results that did work / didn’t show results that didn’t work;

7. Only one set of results / not repeated;

8. Only compared against one washing powder / may not be true for other washing powders;
   Ignore references to unknown masses of powder, temperature of washes or other aspects of technique or different fabrics

(c) 1. Enzyme S effective across a wider range of temperatures;

2. Enzyme S more active above 50 °C / active up to 80 °C / active above 60 °C;

3. Enzyme S more active below (about) 37 °C temperature;

4. (Although) Enzyme P has higher rate of reaction at optimum / 40 – 50 °C;

5. Enzyme P denatured above 50 °C;

   Answers should be in the context of choosing enzyme S but, if P is chosen, points 4 and 5 may still be awarded, if described
   In points 2 and 3, a temperature must be stated. Allow ± 5 degrees of values shown

3 max
(d) 1. Stains caused by different substances;
2. Enzymes are specific;
3. Active site specific to substrate / other substrates cannot fit active site;
   
   *This could be expressed in other ways e.g. 'other substrates are not complementary to the active site'*

(a) 1. Separates / unwinds / unzips strands / helix / breaks H-bonds;
   1. Q Neutral: strands / helix split
   1. Accept: unzips bases
   2. (So) nucleotides can attach / are attracted / strands can act as templates;
      2. Q Neutral: bases can attach
      2. Neutral: helix can act as a template

(b)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Type(s) of DNA molecule present in each tube</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$^{15}\text{N} / ^{15}\text{N}$</td>
</tr>
<tr>
<td>1</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

One mark for each correct row

(c) 1. Similar shape / structure (to cytosine) / added instead of cytosine / binds to guanine;
   1. Accept: idea that *only one group is different*
   1. Reject: same shape

   2. Prevents (complementary) base pairing / prevents H-bonds forming / prevents formation of new strand / prevents strand elongation / inhibits / binds to (DNA) polymerase;
   2. Accept: prevents cytosine binding

   *Neutral: 'prevents DNA replication' as given in the question stem*
   Neutral: 'competitive inhibitor' unqualified
   Neutral: inhibits DNA helicase
(ii) (Cancer cells / DNA) divide / replicate fast(er) / uncontrollably;

Accept: converse argument for healthy cells

(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.

(b) (i) 15

Correct answer = 2 marks.

Allow 1 mark for showing

\[69 \div 4.6\]

OR

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

(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.

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

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

(b) Add 4.5 cm$^3$ of (1.0 mol dm$^{-3}$) solution to 25.5 cm$^3$ (distilled) water. 
*If incorrect, allow 1 mark for solution to water in a proportion of 0.15:0.85*

(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.

(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).
(a) Bacteria killed;
   *Ignore: no growth or growth of bacteria prevented.*
   *Accept: bacteria destroyed.*
   *Accept: no living bacteria.*

(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.*

(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.*

(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.

(a) 1. Rank all STs in ascending order;
  2. Find value with same number (of people) above and below.
   *Accept find middle value*

(b) Not ethical to fail to treat cancer.
(c) Yes since with ipilimumab:

1. Median ST increased by 2.1 months;
2. Percentage of patients showing reduction in tumours increased from 10.3% to 15.2%;

No because:
3. No standard errors shown / no (Student) t-test / no statistical test carried out;
4. (So) not able to tell if differences are (statistically) significant / due to chance (alone);
5. Improvement might only be evident in some patients / no improvement in some patients;
6. Quality of (extra) time alive not reported;

If answers relate only to ‘Yes’ or ‘No’, award 2 marks max

(d) 1. Faulty protein recognised as an antigen / as a ‘foreign’ protein;
2. T cells will bind to faulty protein / to (this) ‘foreign’ protein;
3. (Sensitised) T cells will stimulate clonal selection of B cells;
4. (Resulting in) release of antibodies against faulty protein.

3 max

(a) 1. water evaporates / transpires from leaves;
2. reduces water potential in cell / water potential / osmotic gradient across cells (ignore reference to air space);
3. water is drawn out of xylem;
4. creates tension (accept negative pressure, not reduced pressure);
5. cohesive forces between water molecules;
6. water pulled up as a column;

4 max

7 (b) (i) same surface area of leaf / number of leaves / age / thickness of cuticle;

(i) (environmental conditions) affect rate of transpiration / evaporation;

(iii) presence of grease reduces water loss;

(c) (i) 1.2 / 1.3g;

(ii) more stomata on the lower surface;
(thicker) waxy cuticle on the upper surface;

2 [10]
(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;

(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]

(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.*

(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.*

(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.*
(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

(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.*

(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;

(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.*

(a) generation of random co-ordinates;

use of 10 or more quadrats;

*collection of all dog whelks in quadrat;*

(b) greater variation for sheltered population / population A;

range / spread around the *mean;*

*(or converse)*

(c) (i) smaller ratio means relatively larger foot / population B has relatively large foot;

better able to grip;

larger / longer shells have greater area exposed / are subject to greater force;
(ii) wave action limits the max. L / A ratio / extremes;
valid point about age, e.g. greater age range on sheltered
shore / live longer on sheltered shore;

(allow shell size marking point in either (c)(i)
or (c)(ii) but only credit once)
Examiner reports

(a) There was some weakness with both the answers to this question and the assessment of what was written. As mentioned before, marking points show the minimum required answer and marking point 1 clearly identified that amino acids would be formed. It was disappointing that quite a few assessors felt that “smaller proteins are formed” or simply that “proteins are digested” was sufficient to award this marking point.

(b) In the main, students used the information provided well to answer this question. The majority referred to trusted ideas such as the limited number of stains used or that there was only a single set of results. Higher scoring students used the more sophisticated arguments, such as not including results where there was no change, and made specific reference to the actual stains.

(c) It was also the case that many students answered this question well, particularly where appropriate temperatures were identified to support the use of enzyme S or to explain why enzyme P was inappropriate for use. However, the general idea, that enzyme S was effective across a wider range of temperatures, was often not recognised.

(d) Many students finished with full credit in this question. In weaker answers, as was often the case with many questions, students failed to translate the idea in the question first. Thus, ‘a wider range of stains’ was not explained as caused by different substances being present but this did not prevent most being able to identify that the specific nature of enzymes was due to their active site.

1  This proved to be a good discriminator. Most students were aware that DNA helicase separates strands or breaks hydrogen bonds. However, only better responses went on to state that this allows nucleotides to attach or the strands to act as templates. Unfortunately, poor expression or a lack of precision let down some students. This was usually for DNA ‘splitting’, or ‘bases’, rather than nucleotides, attaching.

(b) Just under half of students gained full credit.

(c) (i) This proved to be a good discriminator. A quarter of students scored full marks. Most were aware that cytarabine has a similar structure to cytosine. However, weaker responses were often vague regarding the subsequent effect of this, eg ‘prevents DNA replication’ or ‘inhibits helicase’. Similarly, there were many unqualified references to cytarabine acting as a competitive inhibitor. It was only the best responses that suggested cytarabine may prevent base pairing, prevent the formation of a new strand or act as an inhibitor of DNA polymerase.

(ii) Just over seventy percent of students were aware that cancer cells divide faster than healthy cells.
(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.

(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.
(a) There were some very good answers achieving maximum marks. However, many answers used very vague language, such as ‘water is pulled up by cohesion-tension’, with no description of what cohesion involves, or what creates the tension. Water was said by many to be ‘sticky’. This was the lowest level of answer accepted for a mark about cohesion. Root pressure was often included in the description of cohesion-tension, which cost candidates time but gained no credit.

(b) (i) Many candidates appear to confuse the concept of fair testing with reliability; both terms being used interchangeably.

(ii) More able candidates answered in terms of how an environmental variable could affect the rate of transpiration, or the rate of evaporation, rather than just stating ‘to keep water loss the same’.

(iii) Most candidates gave the correct answer.

(c) (i) Most candidates calculated the mass of water lost accurately.

(ii) Many candidates missed marks by failing to give a comparison between the upper and lower surfaces of leaves. There were many references to ‘pores’ rather than ‘stomata’, or a ‘waxy layer’ rather than a ‘cuticle’, indicating a poor knowledge of leaf structure.

(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.

(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.
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.

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.

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.

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.

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.
(a) This question proved a good discriminator with a surprising range of answers being produced. Candidates appeared not fully to appreciate the question, with many having difficulty applying a standard technique to an unfamiliar situation. A number of candidates described setting up transects without reference to the random nature of the sample to be obtained, references to counting were common and many failed to suggest a sufficient number of quadrats. A few resorted to throwing the quadrats over their shoulder, some doing so even after describing how to produce random co-ordinates.

(b) This question was generally well answered with most candidates gaining two marks. Weaker answers confused the data with probability values.

(c) (i) This was generally poorly answered. Most gained a mark for linking the foot or aperture size with grip but few answers were clearly expressed, with only the best candidates discussing both aperture and shell size. There were confused ideas attributing smaller shell size to erosion by waves.

(ii) Answers to this question were disappointing with few candidates being able to amplify their understanding of standard deviation. Only the better candidates recognised the point of the question and were able to appreciate the effect of wave action on limiting the range of sizes. The idea of size being age-related and linked to situation was rarely given.