**Q1.**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).

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Hamsterage group** | **Number ofhamsters ingroup** | **Mean number of capillaries associatedwith 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)**

(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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**(4)**

**(Total 12 marks)**

 **Q2.**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.

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Treatment** | **Median survival time (ST) / months** | **Percentage of patients showing significant reduction in tumours** |
|   | Dacarbazine | 9.1 | 10.3 |
|   | Dacarbazine and ipilimumab | 11.2 | 15.2 |

(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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**(2)**

(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)**

(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)**

**Q3.**There are two types of diabetes: type 1 and type 2.

•        People with type 1 diabetes do not produce enough insulin.

•        People with type 2 diabetes do produce insulin but have cells which do not respond to insulin.

Doctors use a glucose tolerance test to help diagnose people with diabetes. They start each test after a person has not eaten overnight. They measure a person’s blood glucose concentration.

The person then drinks a solution containing 75 g of glucose. The doctors measure the person’s blood glucose concentration 2 hours later. During the test, the person remains at rest.

**Figure 1** shows three diagnoses that can be made from the results of the test.

**Figure 1 – glucose tolerance test results and diagnoses**

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Blood glucoseconcentration after 2 hours/ mg 100 cm–3** | **Diagnosis** | **Comments** |
|   | ≤ 110 | Non-diabetic | Low risk for future diabetes |
|   | Between 140 and 200 | Pre-diabetic | High risk for future diabetes.Some doctors recommend that theupper value should be lowered to180 mg 100 cm–3 |
|   | ≥ 200 | Diabetic | Confirm by doing a second test |

A researcher monitored the mean blood glucose concentration of a non-diabetic, a pre-diabetic and a diabetic after they had each eaten a midday meal.

His results are shown in **Figure 2**.

**Figure 2**

 

(a)     People with type 1 diabetes are described as being insulin-dependent.
Suggest why they are described as insulin-dependent.

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**(1)**

(b)     Some people with type 2 diabetes have cells which do **not** respond to insulin.
Explain how this leads to a reduced ability to regulate blood glucose concentration.

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**(3)**

(c)     During a glucose tolerance test the person remains at rest.
Why is it important that the person remains at rest?

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**(2)**

(d)     Use **Figure 2** to calculate how many times the maximum mean blood glucose concentration of the pre-diabetic is greater than the maximum of the non-diabetic person. Show your working.

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

**(2)**

(e)     Give **three** differences between the method used by the researcher to obtain the results in **Figure 2** and the method doctors use to carry out a glucose tolerance test.

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**(3)**

(f)     Some doctors have recommended that the upper value used in the glucose tolerance test should be lowered to 180 mg 100 cm–3.
Using information from **Figure 1** and **Figure 2**, suggest why.

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**(3)**

**(Total 14 marks)**

**Q4.**(a)     What is a *species?*

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**(2)**

(b)     Scientists investigated the diversity of plants in a small area within a forest. The table shows their results.

|  |  |  |
| --- | --- | --- |
|   | **Plant species** | **Number of individuals** |
|   | Himalayan raspberry | 20 |
|   | Heartwing sorrel | 15 |
|   | Shala tree | 9 |
|   | Tussock grass | 10 |
|   | Red cedar | 4 |
|   | Asan tree | 6 |
|   | Spanish needle | 8 |
|   | Feverfew | 8 |

The index of diversity can be calculated by the formula



where

*d* = index of diversity
*N* = total number of organisms of all species
*n* = total number of organisms of each species

(i)      Use the formula to calculate the index of diversity of plants in the forest. Show your working.

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

**(2)**

(ii)     The forest was cleared to make more land available for agriculture.

After the forest was cleared the species diversity of insects in the area decreased. Explain why.

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**(3)**

**(Total 7 marks)**

**Q5.**Doctors investigated the effect of the smoking habits of men on their non-smoking wives.

The doctors recruited 540 non-smoking women aged 40 or older. They divided these women into groups according to the smoking habits of their husbands.
After 14 years, the doctors recorded how many of the wives had died and their cause of death.

They used these data to determine the relative risk of a wife dying from a particular disease according to her husband’s smoking habit.

In this comparison, they gave the relative risk to the wife of a non-smoker as 1.00. A value greater than 1.00 shows an increased risk compared to the wife of a non-smoker.

The results are shown in the table below.

|  |  |  |
| --- | --- | --- |
|   | **Cause ofdeath** | **Relative risk of wife dying** |
|   | **Husbandnon-smoker** | **Husband smokes 1 to 19 cigarettes /day** | **Husband smokes more than 19 cigarettes / day** |
|   | Lung cancer | 1.00 | 1.61 | 2.08 |
|   | Emphysema | 1.00 | 1.29 | 1.49 |
|   | Cervical cancer | 1.00 | 1.15 | 1.14 |
|   | Stomach cancer | 1.00 | 1.02 | 0.99 |
|   | Heart disease | 1.00 | 0.97 | 1.03 |

A journalist concluded from these data that if a husband smoked, it greatly increased the risk of his wife dying of certain diseases. Evaluate this statement.

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**(Total 4 marks)**

**Q6.**(a)    The table shows three statements about some biological molecules. Complete the table with a tick in each box if the statement is true for haemoglobin, cellulose or starch.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Statement** | **Haemoglobin** | **Cellulose** | **Starch** |
|   | Has a quaternary structure |   |   |   |
|   | Formed by condensation reactions |   |   |   |
|   | Contains nitrogen |   |   |   |

**(3)**

The graph shows oxygen dissociation curves for the haemoglobin of a mother and her fetus.



Partial pressure of oxygen (pO2) / kPa

(b)     What is the difference in percentage saturation between the haemoglobin of the mother and her fetus at a partial pressure of oxygen (pO2) of 4 kPa?

 

**(1)**

(c)     The oxygen dissociation curve of the fetus is to the left of that for its mother. Explain the advantage of this for the fetus.

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**(2)**

(d)     After birth, fetal haemoglobin is replaced with adult haemoglobin. Use the graph to suggest the advantage of this to the baby.

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**(2)**

(e)     Hereditary persistence of fetal haemoglobin (HPFH) is a condition in which production of fetal haemoglobin continues into adulthood. Adult haemoglobin is also produced.

People with HPFH do not usually show symptoms. Suggest why.

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**(1)**

**(Total 9 marks)**

 **Q7.**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 the table below.

|  |  |  |
| --- | --- | --- |
|   | **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 | 290.7 (± 2.1) | 111.1 (± 0.1) |
|   | Chlorophyll c | 0.10 (± 0.01) | 0.07 (± 0.01) |

 (a)     Describe how you would present the data in the table as a graph.

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**(2)**

(b)     The ecologist collected shade leaves at random from a branch.
Suggest a method he could have used to collect shade leaves at random from a branch.

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**(2)**

(c)     The ecologist concluded that there is a significant difference between the amounts of chlorophyll b in sun leaves and shade leaves of beech trees.

Do you agree with this conclusion?

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**(2)**

(d)     Each type of chlorophyll is produced by a specific enzyme-controlled pathway.
Use this information to suggest how the same beech tree can produce more chlorophyll b in some leaf cells than others.

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**(2)**

**(Total 8 marks)**

**Q8.**(a)     Describe and explain how the countercurrent system leads to efficient gas exchange across the gills of a fish.

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**(3)**

(b)     Amoebic gill disease (AGD) is caused by a parasite that lives on the gills of some species of fish. The disease causes the lamellae to become thicker and to fuse together.

AGD reduces the efficiency of gas exchange in fish. Give **two** reasons why.

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

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

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**(2)**

(c)     The table below shows some features of gas exchange of a fish at rest.

|  |  |  |
| --- | --- | --- |
|   | Volume of oxygen absorbed by the gills from each dm3 of water / cm3 | 7 |
|   | Mass of fish / kg | 0.4 |
|   | Oxygen required by fish / cm3 kg–1 hour–1 | 90 |

(i)      Calculate the volume of water that would have to pass over the gills each hour to supply the oxygen required by the fish. Show your working.

.......................................................... dm3

**(2)**

(ii)     The volume of water passing over the gills increases if the temperature of the water increases. Suggest why.

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**(1)**

**(Total 8 marks)**

 **Q9.**Scientists measured the rate of respiration in **three** parts of an ecosystem.

They did this by measuring carbon dioxide released into the air by:

•        leaves of plants

•        stems and roots of plants

•        non-photosynthetic soil organisms.

The table below shows the scientists’ results for these three parts of the ecosystem.

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Part ofecosystem** | **Mean rate ofcarbon dioxideproduction /cm3 m−2 s−1** | **Percentage oftotal carbon dioxideproduction measuredby the scientists** |
|   | Leaves ofplants | 0.032 | 25.0 |
|   | Stems androots of plants | 0.051 |   |
|   | Non-photosyntheticsoil organisms | 0.045 |   |

(a)     Complete the table to show the percentage of total carbon dioxide production by each part of the ecosystem.

Show your working.

**(2)**

(b)     A student who looked at the data in the table concluded that plants carry out more respiration than non-photosynthetic organisms in the ecosystem.

Use the information provided to suggest why these data may **not** support the student’s conclusion.

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**(2)**

(c)     What measurements would the scientists have made in order to calculate the rate of carbon dioxide production?

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**(2)**

(d)     The scientists calculated the mean rate of carbon dioxide production of the leaves using measurements of carbon dioxide release in the dark.

Explain why they did **not** use measurements taken in the light.

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**(2)**

Another group of scientists measured the mean rate of respiration in soil under trees and soil not under trees in the same wood. They also measured the mean rate of photosynthesis in the trees.

They took measurements at different times of day during the summer.

The figure below shows the scientists’ results.


          Time of day

(e)     (i)      Describe **two** ways in which the mean rate of respiration in soil under trees is different from soil not under trees.

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

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

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**(2)**

(ii)     Suggest **one** explanation for the differences in the mean rate of respiration in soil under trees and soil not under trees between 06.00 and 12.00.

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**(2)**

(f)     The scientists suggested that the rise in the mean rate of photosynthesis was the cause of the rise in the mean rate of respiration in soil under trees.

(i)      Suggest how the rise in the mean rate of photosynthesis could lead to the rise in the mean rate of respiration in soil under trees.

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**(2)**

(ii)     Suggest why there is a delay between the rise in the mean rate of photosynthesis and the rise in the mean rate of respiration.

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**(1)**

**(Total 15 marks)**

**Q10.**Scientists wanted to measure how much mRNA was transcribed from allele **A** of a gene in a sample of cells. This gene exists in two forms, **A** and **a**.

The scientists isolated mRNA from the cells. They added an enzyme to mRNA to produce cDNA.

(a)     Name the type of enzyme used to produce the cDNA.

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**(1)**

The scientists used the polymerase chain reaction (PCR) to produce copies of the cDNA. They added a DNA probe for allele **A** to the cDNA copies. This DNA probe had a dye attached to it. This dye glows with a green light **only** when the DNA probe is attached to its target cDNA.

(b)     Explain why this DNA probe will only detect allele **A**.

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**(2)**

(c)     The scientists used this method with cells from two people, **H** and **G**.
One person was homozygous, **AA**, and the other was heterozygous, **Aa**.
The scientists used the PCR and the DNA probe specific for allele **A** on the cDNA from both people.

The figure shows the scientists’ results.



(i)      Explain the curve for person **H**.

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**(3)**

(ii)     Which person, **H** or **G**, was heterozygous, **Aa**? Explain your answer.

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**(2)**

**(Total 8 marks)**

 **Q11.**(a)     When insulin binds to receptors on liver cells, it leads to the formation of glycogen from glucose. This lowers the concentration of glucose in liver cells.

Explain how the formation of glycogen in liver cells leads to a lowering of blood glucose concentration.

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**(2)**

People with type II diabetes have cells with low sensitivity to insulin. About 80% of people with type II diabetes are overweight or obese. Some people who are obese have gastric bypass surgery (GBS) to help them to lose weight.

Doctors investigated whether GBS affected sensitivity to insulin. They measured patients’ sensitivity to insulin before and after GBS. About half of the patients had type II diabetes. The other half did not but were considered at high risk of developing the condition.

The table below shows the doctors’ results. The higher the number, the greater the sensitivity to insulin.

|  |  |  |
| --- | --- | --- |
|    | **Patients** | **Mean sensitivity to insulin /arbitrary units(± SD)** |
|   | **Before gastricbypasssurgery** | **1 month aftergastric bypasssurgery** |
|   | Did not havediabetes |     0.55(± 0.32) |     1.30(± 0.88) |
|   | Had type IIdiabetes |     0.40(± 0.24) |     1.10(± 0.87) |

(b)     The doctors concluded that many of the patients who did not have type II diabetes were at high risk of developing the condition.

Use the data in the table to suggest why they reached this conclusion.

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**(2)**

(c)     The doctors also concluded that GBS cured many patients’ diabetes but that some were not helped very much.

Do these data support this conclusion? Give reasons for your answer.

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**(3)**

**(Total 7 marks)**

 **Q12.**Hydrilla (*Hydrilla verticillata*) is an aquatic plant which has become a major pest of waterways in parts of the USA. Hydrilla is not a native species of the USA. It was introduced into natural habitats from aquariums. In many freshwater habitats it has rapidly become the dominant plant species.

(a)     In many freshwater habitats Hydrilla has rapidly become the dominant plant species.
Suggest **two** reasons why.

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

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

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**(2)**

(b)     The spread of Hydrilla has had economic consequences for commercial activities and for the government’s environmental agency.
Suggest **two** economic consequences of the spread of Hydrilla.

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

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

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**(2)**

(c)     Scientists investigated the effect of the chemical fluridone as a method of controlling Hydrilla. The study was carried out using samples of Hydrilla grown under controlled laboratory conditions. Several samples of the plant were grown at different concentrations of fluridone. The results are shown in the following table.

|  |  |  |
| --- | --- | --- |
|   |  | **Days of treatment** |
|   | 0 | 20 | 40 | 60 |
|   | **Concentration offluridone / μg dm–3** | **Mean biomass of Hydrilla / g** |
|   |   0.0 | 5.0 | 16.4 | 20.4 | 33.4 |
|   |   0.5 | 5.0 | 14.1 | 18.2 | 31.3 |
|   |   1.0 | 5.0 |   9.7 |   8.9 |   7.4 |
|   |   5.0 | 5.0 |   4.6 |   2.8 |   1.3 |
|   | 25.0 | 5.0 |   3.2 |   1.6 |   0.4 |

(i)      The scientists obtained the biomass of each sample by heating it at 75 °C for 2 hours.
They then weighed the sample, reheated it for 15 minutes and weighed it again. They continued this cycle of reheating and weighing until they found the sample had a constant mass.

Explain how this method helped to provide a reliable measurement of the biomass.

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**(2)**

(ii)     A scientist reviewed the results of this investigation. He suggested that fluridone should be used in the habitat at a concentration of 5.0 μg dm–3 rather than at the other concentrations tested. Use the information provided and your knowledge of chemical control to explain why he made this suggestion.

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**(4)**

(d)     Scientists have also investigated the use of an integrated system to control Hydrilla.
This involved using fluridone and a fungus as a biological control agent. They set up four different experiments.

•        Experiment **1** – Hydrilla left untreated

•        Experiment **2** – Hydrilla treated with the fungus

•        Experiment **3** – Hydrilla treated with fluridone

•        Experiment **4** – Hydrilla treated with both fluridone and the fungus.

The scientists determined the biomass of Hydrilla at the end of each experiment.

(i)      Experiment **1** acted as a control. Explain why the scientists carried out experiment **1**.

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**(1)**

(ii)     The scientists isolated the fungus from the tissue of Hydrilla growing in its country of origin. Suggest **two** possible advantages of using this fungus as the biological control agent.

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

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

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**(2)**

(iii)    The treatment in experiment **4** was the most effective. Use your knowledge of integrated pest control systems to suggest why the treatment in experiment **4** was the most effective.

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**(2)**

**(Total 15 marks)**

**Q13.**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 gascollected / 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)**

**Q14.**The table shows the taxons and the names of the taxons used to classify one species of otter. They are **not** in the correct order.

|  |  |  |  |
| --- | --- | --- | --- |
|   |   | **Taxon** | **Name of taxon** |
|   | **J** | Family | Mustelidae |
|   | **K** | Kingdom | Animalia |
|   | **L** | Genus | Lutra |
|   | **M** | Class | Mammalia |
|   | **N** | Order | Carnivora |
|   | **O** | Phylum | Chordata |
|   | **P** | Domain | Eukarya |
|   | **Q** | Species | lutra |

(a)     Put letters from the table above into the boxes in the correct order. Some boxes have been completed for you.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |   | **O** |   | **M** |   |   |   |   |   | **L** |   | **Q** |

**(1)**

(b)     Give the scientific name of this otter.

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**(1)**

Scientists investigated the effect of hunting on the genetic diversity of otters. Otters are animals that were killed in very large numbers for their fur in the past.

The scientists obtained DNA from otters alive today and otters that were alive before hunting started.

For each sample of DNA, they recorded the number of base pairs in alleles of the same gene. Mutations change the numbers of base pairs over time.

The figure below shows the scientists’ results.


                        Allele size / number of base pairs

(c)     The scientists obtained DNA from otters that were alive before hunting started.

Suggest **one** source of this DNA.

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**(1)**

(d)     What can you conclude about the effect of hunting on genetic diversity in otters? Use data from the figure above to support your answer.

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**(2)**

(e)     Some populations of animals that have never been hunted show very low levels of genetic diversity.

Other than hunting, suggest **two** reasons why populations might show very low levels of genetic diversity.

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

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

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**(2)**

**(Total 7 marks)**

**Q15.**Nicotine is the addictive substance in tobacco. When nicotine reaches the brain, it binds to a specific protein. This causes the release of chemicals that give a feeling of reward to the smoker. This reward is part of the reason why people find it difficult to stop smoking.

Scientists have developed a vaccine against nicotine to help people stop smoking.
They set up an investigation, which involved a large number of volunteers. Once a month for 5 months, one group of volunteers was given the vaccine and the other group was given a placebo.

At regular intervals, the scientists measured the concentration of antibodies to nicotine in the blood of each group of volunteers. They also calculated the percentage of volunteers who had stopped smoking from months 2 to 6 of the investigation.

(a)     (i)      In this investigation, neither the volunteers nor the scientists knew if a particular volunteer was receiving the vaccine or a placebo.

Suggest **two** reasons why this made the scientists’ results more reliable.

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

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

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**(2)**

(ii)     The scientists measured the concentration of nicotine in the blood of two volunteers who smoked the same number of cigarettes per day.

Suggest **two** reasons why the concentration of nicotine in the blood of these smokers might be different.

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

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**(2)**

(b)     (i)      Suggest how this vaccine could help people to stop smoking.

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**(3)**

(ii)     Some people have suggested that this vaccine should **not** be given free to smokers on the National Health Service (NHS). Evaluate this suggestion.

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**(3)**

The scientists measured the concentration of antibodies to nicotine in the blood of the volunteers for 12 months after the first vaccination. As a result of these measurements, they divided the volunteers who received the nicotine vaccine into three groups:

•        high antibody responders

•        medium antibody responders

•        low antibody responders.

The figure below shows their results.

The scientists also recorded the number of volunteers who had stopped smoking from months 2 to 6 of the investigation.

The table below shows these results.

 
Month when vaccine or placebo was given

|  |  |  |
| --- | --- | --- |
|   | **Group** | **Percentage of volunteerswho had stopped smoking frommonths 2 to 6 of the investigation** |
|   | High antibody responders | 56.6 |
|   | Low antibody responders | 38.1 |
|   | Medium antibody responders | 32.1 |
|   | Placebo | 31.3 |

(c)     A journalist reported that this vaccine is a major breakthrough in helping people to stop smoking. Do these data support this statement? Explain your answer.

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**(5)**

**(Total 15 marks)**

**Q16.**(a)     Explain how the structure of DNA is related to its functions.

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**(6)**

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division.
They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

•        If a person had a normal allele for a gene, they used the symbol N.

•        If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no increased risk. The following table shows the scientists’ results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Gene C** | **Gene D** | **Gene E** | **Risk ofdevelopinglung cancer** |
|   | N | N | N | 1.00 |
|   | M | N | N | 1.30 |
|   | N | N | M | 1.78 |
|   | N | M | N | 1.45 |
|   | N = at least one copy of the normal allele is presentM = two copies of the mutant allele are present |

(b)     What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

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**(3)**

Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.

 
                                    Time / days

(c)     Calculate the rate at which healthy cells were killed between days 42 and 46.

.............. cells killed per unit volume of blood per day

**(1)**

(d)     Describe similarities and differences in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

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**(3)**

(e)     More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

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**(2)**

**(Total 15 marks)**

**Q17.**Scientists investigated the effect of a mycorrhizal fungus on the growth of pea plants with a nitrate fertiliser or an ammonium fertiliser. The fertilisers were identical, except for nitrate or ammonium.

The scientists took pea seeds and sterilised their surfaces. They planted the seeds in soil that had been heated to 85 °C for 2 days before use. The soil was sand that contained no mineral ions useful to the plants.

(a)     Explain why the scientists sterilised the surfaces of the seeds and grew them in soil that had been heated to 85 °C for 2 days.

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**(2)**

(b)     Explain why it was important that the soil contained no mineral ions useful to the plants.

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**(1)**

The pea plants were divided into four groups, **A**, **B**, **C** and **D**.

•        **Group A** – heat-treated mycorrhizal fungus added, nitrate fertiliser

•        **Group B** – mycorrhizal fungus added, nitrate fertiliser

•        **Group C** – heat-treated mycorrhizal fungus added, ammonium fertiliser

•        **Group D** – mycorrhizal fungus added, ammonium fertiliser

The heat-treated fungus had been heated to 120 °C for 1 hour.

(c)     Explain how groups **A** and **C** act as controls.

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**(2)**

After 6 weeks, the scientists removed the plants from the soil and cut the roots from the shoots. They dried the plant material in an oven at 90 °C for 3 days. They then determined the mean dry masses of the roots and shoots of each group of pea plants.

(d)     Suggest what the scientists should have done during the drying process to be sure that all of the water had been removed from the plant samples.

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**(2)**

The scientists’ results are shown in the table below.

|  |  |  |
| --- | --- | --- |
|   | **Treatment** | **Mean dry mass / g per plant( standard deviation)** |
|   | **Root** | **Shoot** |
|   | **A** – heat-treated fungus and nitrate fertiliser | 0.40(±0.05) | 1.01(±0.12) |
|   | **B** – fungus and nitrate fertiliser | 1.61(±0.28) | 9.81(±0.33) |
|   | **C** – heat-treated fungus and ammonium fertiliser | 0.34(±0.03) | 0.96(±0.26) |
|   | **D** – fungus and ammonium fertiliser | 0.96(±0.18) | 4.01(±0.47) |

(e)     What conclusions can be drawn from the data in the table about the following?

The effects of the fungus on growth of the pea plants.

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The effects of nitrate fertiliser and ammonium fertiliser on growth of the pea plants.

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**(4)**

The scientists determined the dry mass of the roots and shoots separately. The reason for this was they were interested in the ratio of shoot to root growth of pea plants. It is the shoot of the pea plant that is harvested for commercial purposes.

(f)     Explain why determination of dry mass was an appropriate method to use in this investigation.

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**(2)**

(g)     Which treatment gave the best result in commercial terms? Justify your answer.

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**(2)**

**(Total 15 marks)**

 **Q18.**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.

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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)**

**Q19.**Ecologists investigated the size of an insect population on a small island. They used a mark-release-recapture method. To mark the insects they used a fluorescent powder. This powder glows bright red when exposed to ultraviolet (UV) light.

(a)     The ecologists captured insects from a number of sites on the island. Suggest how they decided where to take their samples.

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**(2)**

(b)     Give **two** assumptions made when using the mark-release-recapture method.

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**(2)**

(c)     Suggest the advantage of using the fluorescent powder in this experiment.

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**(2)**

The ecologists did **not** release any of the insects they captured 1–5 days after release of the marked insects.

The table below shows the ecologists’ results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Days after release** | **Number of marked insects remainingin population** | **Number of insectscaptured** | **Number of captured insects that were marked** |
|   | 1 | 1508 | 524 | 78 |
|   | 2 | 1430 | 421 | 30 |
|   | 3 | 1400 | 418 | 18 |
|   | 4 | 1382 | 284 | 2 |
|   | 5 | 1380 | 232 | 9 |

(d)     Calculate the number of insects on this island 1 day after release of the marked insects.

Show your working.

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

**(2)**

(e)     The ecologists expected to obtain the same result from their calculations of the number of insects on this island on each day during the period 1–5 days after release. In fact, their estimated number increased after day 1.

During the same period, the number of insects they caught decreased.

The method used by the ecologists might have caused these changes.

Use the information provided to suggest **one** way in which the method used by the ecologists might have caused the increase in their estimates of the size of the insect population.

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**(2)**

**(Total 10 marks)**

 **Q20.Table 1** shows how a bird called the bluethroat (*Luscinia svecica*) is classified by biologists.

**Table 1**

|  |  |  |
| --- | --- | --- |
|   | **Taxon** | **Name of taxon** |
|   | Domain | Eukaryota |
|   |  | Animalia |
|   |  | Chordata |
|   |  | Aves |
|   |  | Passeriformes |
|   |  | Muscicapidae |
|   | Genus |  |
|   | Species |  |

(a)     Complete **Table 1** by filling the seven blank spaces with the correct terms.

**(2)**

A group of scientists investigated genetic diversity in different species of bird. For each species, the scientists:

•        collected feathers from a large number of birds

•        extracted DNA from cells attached to each feather

•        analysed the samples of DNA to find genetic diversity.

**Table 2** summarises their results.

**Table 2**

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Species of bird** | **Number of genes examined** | **Number of genes examined that showedgenetic diversity** |
|   | Willow flycatcher | 708 | 197 |
|   | House finch | 269 | 80 |
|   | Bluethroat | 232 | 81 |

(b)     In this investigation, what is meant by **genetic diversity?**

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**(1)**

(c)     The scientists concluded that the bluethroat showed greater genetic diversity than the willow flycatcher. Explain why they reached this conclusion. Use calculations to support your answer.

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**(2)**

**(Total 5 marks)**

**Q21.**The following figure represents part of a DNA molecule.

 

(a)     Draw a box around a single nucleotide.

**(1)**

The table below shows the percentage of bases in each of the strands of a DNA molecule.

|  |  |  |
| --- | --- | --- |
|   | **DNA strand** | **Percentage of each base** |
|   | **A** | **C** | **G** | **T** |
|   | Strand **1** | 16 |  |   |   |
|   | Strand **2** |   | 21 | 34 |   |

(b)     Complete the table by adding the missing values.

**(2)**

(c)     During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5’ to 3’ direction.

Use the figure in part **(a)** and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5’ to 3’ direction.

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**(4)**

**(Total 7 marks)**

**Q22.**(a)     Contrast the processes of facilitated diffusion and active transport.

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**(3)**

Students investigated the uptake of chloride ions in barley plants. They divided the plants into two groups and placed their roots in solutions containing radioactive chloride ions.

•        Group **A** plants had a substance that inhibited respiration added to the solution.

•        Group **B** plants did not have the substance added to the solution.

The students calculated the total amount of chloride ions absorbed by the plants every 15 minutes. Their results are shown in the figure below.

 
                  Time / minutes

(b)     Calculate the ratio of the mean **rate** of uptake of chloride ions in the first hour to the **rate** of uptake of chloride ions in the second hour for group **B** plants.

Ratio = ................................... :1

**(2)**

(c)     Explain the results shown in the figure above.

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**(4)**

**(Total 9 marks)**

 **Q23.**Species richness and an index of diversity can be used to measure biodiversity within a community.

(a)     What is the difference between these two measures of biodiversity?

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**(1)**

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

•        The canopy traps were set among the leaves of the trees 16–27 m above ground level.

•        The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. The table below summarises their results.

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Species of butterfly** | **Mean number of butterflies** | **P value** |
|   | **In canopy** | **In understorey** |
|   | *Prepona laertes* | 15 | 0 | < 0.001 |
|   | *Archaeopreponademophon* | 14 | 37 | < 0.001 |
|   | *Zaretis itys* | 25 | 11 | > 0.05 |
|   | *Memphis arachne* | 89 | 23 | < 0.001 |
|   | *Memphis offa* | 21 | 3 | < 0.001 |
|   | *Memphis xenocles* | 32 | 8 | < 0.001 |

(b)     The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

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**(1)**

(c)     By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

*d* = 

where *N* is the total number of organisms of all species and *n* is the total number of organisms of each species.

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

**(3)**

(d)     The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in the table.

Explain what the results of these statistical tests show.

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**(3)**

**(Total 8 marks)**

**Q24.**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)**

 **Q25.**(a)     Describe how oxygen in the air reaches capillaries surrounding alveoli in the lungs. Details of breathing are **not** required.

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

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**(4)**

Forced expiratory volume (FEV) is the greatest volume of air a person can breathe out in 1 second.

Forced vital capacity (FVC) is the greatest volume of air a person can breathe out in a single breath.

The figure below shows results for the volume of air breathed out by three groups of people, **A**, **B** and **C**. Group **A** had healthy lungs. Groups **B** and **C** had different lung conditions that affect breathing.

 
                          Time breathing out / s

(b)     Calculate the percentage drop in FEV for group **C** compared with the healthy people.

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

**(1)**

(c)     Asthma affects bronchioles and reduces flow of air in and out of the lungs.
Fibrosis does not affect bronchioles; it reduces the volume of the lungs.

Which group, **B** or **C**, was the one containing people with fibrosis of their lungs? Use the information provided and evidence from the figure above to explain your answer.

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

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**(3)**

**(Total 8 marks)**

 **Q26.**Newborn babies can be fed with breast milk or with formula milk. Both types of milk contain carbohydrates, lipids and proteins.

•        Human breast milk also contains a bile-activated lipase. This enzyme is thought to be inactive in milk but activated by bile in the small intestine of the newborn baby.

•        Formula milk does not contain a bile-activated lipase.

Scientists investigated the benefits of breast milk compared with formula milk.

(a)     The scientists used kittens (newborn cats) as model organisms in their laboratory investigation.

Other than ethical reasons, suggest **two** reasons why they chose to use cats as model organisms.

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

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

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**(2)**

(b)     Before starting their experiments, the scientists confirmed that, like human breast milk, cat’s milk also contained bile-activated lipase.

To do this, they added bile to cat’s milk and monitored the pH of the mixture.

Explain why monitoring the pH of the mixture could show whether the cat’s milk contained lipase.

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**(2)**

The scientists then took 18 kittens. Each kitten had been breastfed by its mother for the previous 48 hours.

The scientists divided the kittens randomly into three groups of six.

•        The kittens in group **1** were fed formula milk.

•        The kittens in group **2** were fed formula milk plus a supplement containing bile-activated lipase.

•        The kittens in group **3** were fed breast milk taken from their mothers.

Each kitten was fed 2 cm3 of milk each hour for 5 days.

The scientists weighed the kittens at the start of the investigation and on each day for 5 days.

The figure below shows the scientists’ results.

 
Type of milk given to kittens

(c)     What can you conclude from the figure about the importance of bile-activated lipase in breast milk?

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

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**(3)**

**(Total 7 marks)**

**Q27.**A technician investigated the effect of temperature on the rate of an enzyme-controlled reaction. At each temperature, he started the reaction using the same concentration of substrate.

The following graph shows his results.

 
                     Time after start of reaction / minutes

(a)     Give **two** other factors the technician would have controlled.

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

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

**(1)**

(b)     Draw a tangent on each curve to find the initial rates of reaction.
Use these values to calculate the ratio of the initial rates of reaction at 60 °C : 37 °C.
Show your working.

Ratio = ................................... :1

**(2)**

(c)     Explain the difference in the initial rate of reaction at 60 °C and 37 °C.

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**(2)**

(d)     Explain the difference in the rates of reaction at 60 °C and 37 °C between 20 and 40 minutes.

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

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**(4)**

**(Total 9 marks)**

**M1.**(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]**

**M2.**(a)     1.      Rank all STs in ascending order;

2.      Find value with same number (of people) above and below.

*Accept find middle value*

**2**

(b)     Not ethical to fail to treat cancer.

**1**

(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 ߢNo’, award 2 marks max*

**4 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**

**[10]**

**M3.**(a)     Treatment requires person receiving insulin (in some way);

*Accept descriptions e.g. insulin injection*

*Reward idea that insulin must be received, not that it isn’t being produced*

**1**

(b)     1.      No / fewer / abnormal receptors on (cell) membrane;

2.      (So) fewer (glucose) transport proteins;

3.      (So) less glucose can enter (cells);

4.      (So) less glucose converted to glycogen;

*Accept no / fewer enzymes (for this conversion) are activated*

5.      (So, without treatment) blood glucose concentration not lowered when high / above normal;

*Accept converse*

**3 max**

(c)     1.      Movement uses muscles;

2.      Movement increases (rate of) respiration;

3.      Respiration uses glucose / respiration reduces blood glucose concentration;

**2 max**

(d)     1.      Identification of 195 ± 2 and 113 ± 2;

2.      Answer within range of 1.67 to 1.77 (times greater);

*Ignore numbers after two decimal places*

*Correct answer = 2 marks*

**2**

(e)     1.      Meal / uncontrolled intake v 75 g glucose / controlled intake;

*Must have both sides of the story for each point. Marking guidance shows researcher’s method first*

*Idea of could eat anything in meal as against just glucose*

2.      (Concentration) measured over 6 hours / 6+ hours / longer v measured at 2 hours;

3.      (After intake) regular monitoring / several measurements v only measured once / at 2 hours only;

4.      No fasting v fasting before test;

*Credit other descriptions of fasting e.g. went without food as opposed to didn’t have to*

5.      Not (necessarily) at rest v remained at rest;

6.      Tested during afternoon v tested in morning;

*Accept idea of tested at different times of the day*

**3 max**

(f)     1.      Pre-diabetics are at risk of developing diabetes / some pre-diabetics reach a concentration of 180 (mg 100 cm−3) after a meal;

2.      Some pre-diabetics will now be classed as diabetic;

3.      Detection leads to treatment (sooner);

4.      Diabetes damages the body / is life-threatening;

*Accept examples of damage e.g. blindness, heart disease*

**3 max**

**[14]**

**M4.**(a)     1.      Group of similar organisms / organisms with similar features / organisms with same genes / chromosomes;

*1. Accept: same number of chromosomes*

*1. Accept: smallest taxonomic group*

*1. Reject: genetically identical. Only allow 1 max if mentioned*

*1.* ***Q*** *Neutral: similar genes / chromosomes*

2.      Reproduce / produce offspring;

*2. Accept: breed / mate*

3.      That are fertile;

*3. Neutral: that are ‘viable’*

*‘Produce fertile offspring’ = 2 marks*

**2 max**

(b)     (i)      Correct answer of 6.97 to 7 = 2 marks;

One mark for 6320 as numerator or 906 as denominator;

**2**

(ii)     1.      Decrease in variety of plants / fewer plant species;

*1. Accept: reference to monoculture or description*

*1. Neutral: fewer plants*

2.      Fewer habitats / niches;

*2. Neutral: fewer homes / less shelter*

3.      Decrease in variety of food / fewer food sources;

*3. Neutral: less food*

*3. Accept: less variety of prey*

**3**

**[7]**

**M5.**FOR

1.      (If the husband smokes) there’s a greater risk of dying from lung cancer / emphysema / cervical cancer;

2.      The more the husband smokes, the greater the risk of dying from lung cancer / emphysema;

3.      Suitable use of figures from the table to illustrate answer;

AGAINST

4.      Little difference in risk of dying of stomach / heart disease;

5.      Other factor (than husband smoking) / named factor might cause death;

6.      Only one sample / further studies needed;

**4 max**

**[4]**

**M6.
**

*One mark for each correct row*

**3**

(b)     16;

**1**

(c)     1.      Higher affinity / loads more oxygen at low / same / high partial pressure / pO2;

2.      (Therefore) oxygen moves from mother / to fetus;

**2**

(d)     1.      Low affinity / oxygen dissociates;

*Assume ‘it’ is adult haemoglobin*

*1. Accept: converse if ‘fetal haemoglobin’ is clearly stated*

2.      (Oxygen) to respiring tissues / muscles / cells;

*2.* ***Q****: Neutral ‘respirate’*

**2**

(e)     Enough adult Hb produced / enough oxygen released / idea that curves / affinities / Hb are similar / more red blood cells produced;

*Neutral: ‘adult Hb is also produced’ as in the question stem*

*Reject: curves / affinities / Hb are the same*

**1**

**[9]**

**M7.**(a)     1.      Bar chart;

2.      Error bars to represent standard deviation (of mean);

3.      Photosynthetic pigment on *x* axis and mass of pigment on *y* axis;

*Accept suitable sketch*

**2 max**

(b)     1.      Number leaves on the branch;

2.      Use random number table / calculator / pick numbers from bag to determine which leaf to pick;

*Accept use of random number generator*

***OR***

3.      Collect large number of leaves;

4.      Pick out of bag with some idea of randomness;

**2**

(c)     No (no mark)

1.      No stats test carried out;

2.      Standard error / 95% confidence interval calculation identified;

*If awarded, student scores 2 marks – for points 1 and 2*

Yes (no mark)

3.      No overlap shown by the standard deviations;

4.      Ranges around mean stated;

*88.6-92.8 and 111.0-111.2 (1 × SD) or 86.5-94.9 and 110.9-111.3
(2 × SD)*

**2 max**

(d)     In shade leaves:

1.      Greater amount of enzyme / enzyme activity (for production of chlorophyll b);

2.      Greater gene expression / transcription of the gene / more mRNA produced / gene switched on;

3.      Greater translation;

4.      Enzyme / substrate is light sensitive – faster rate of reaction with lower light;

**2 max**

**[8]**

**M8.**(a)     1.      Water and blood flow in opposite directions;

*Accept: diagram if clearly annotated*

2.      Maintains concentration / diffusion gradient / equilibrium not reached / water always next to blood with a lower concentration of oxygen;

*Must have the idea of ‘maintaining’ or ‘always’ in reference to concentration / diffusion gradient*

*Accept: constant concentration / diffusion gradient*

3.      Along whole / length of gill / lamellae;

*Accept: gill plate / gill filament*

**3**

(b)     1.      (Thicker lamellae so) greater / longer diffusion distance / pathway;

***Q*** *Neutral: ‘thicker’ diffusion pathway*

2.      (Lamellae fuse so) reduced surface area;

*Accept: reduced SA:VOL*

**2**

(c)     (i)      Correct answer of **5.1** or **5.14(2857)** (dm3) = 2 marks;;

*Allow 1 mark max for an answer of* ***5*** *if the correct answer of* ***5.1*** *or* ***5.14(2857)*** *is* ***not*** *shown*

One mark for incorrect answers that show **36** or **0.4 × 90** or **90 ÷ 7;**

**2**

(ii)     1.      Increased metabolism / respiration / enzyme activity;

*Accept: enzymes work more efficiently*

2.      Less oxygen (dissolved in water);

*Neutral: references to increased kinetic energy (of water molecules)*

**1 max**

**[8]**

**M9.**(a)

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Part ofecosystem** | **Mean rate ofcarbon dioxideproduction / cm3 m−2 s−1** | **Percentage oftotal carbon dioxideproduction measuredby the scientists** |
|   | Leaves of plants | 0.032 | 25.0 |
|   | Stems and roots of plants | 0.051 | **39.8** |
|   | Non-photosyntheticsoil organisms | 0.045 | **35.2** |

2 correct = 2 marks;;

Adding rates to get 0.128 = 1;

*If rounded to 40 and 35 in table;*

*•    but working shows decimal points, then award 2 marks
•    but no working shown, then 1 max*

**2 max**

(b)     1.      Data only include (heterotrophic) soil organisms;

2.      Doesn’t include animals (above ground) / other (non-soil) organisms;

3.      Doesn’t take into account anaerobic respiration;

*Award points in any combination*

*Accept for 1 mark idea that CO2 for leaves doesn’t take into account photosynthesis – not told in dark until part (d)*

**2 max**

(c)     **All three** of following = 2 marks;;

**Two** of them = 1 mark;

Volume of carbon dioxide given off

(From known) area / per m2 / m-2

In a known / set time

*Ignore ‘amount’ / concentration of CO2*

*Accept per second / per unit time*

**2**

(d)     1.      (In the light) photosynthesis / in the dark no photosynthesis;

2.      (In light,) carbon dioxide (from respiration) being used / taken up (by photosynthesis);

**2**

(e)     (i)      (Rate of respiration)

*Assume “it” means soil under trees*

1.      In soil under trees (always) higher;

*Accept converse for soil not under trees*

*Accept ‘in the shade’ means under the trees*

2.      In soil under trees does not rise between 06.00 and 12.00 / in the middle of the day / peaks at 20:00-21.00 / in the evening;

3.      In soil **not** under trees, peaks at about 14:00-15:00 / in middle of day;

*2. and 3. No mm grid, so accept ‘between 18.00 and 24.00’ or ‘between 12.00 and 18.00’*

**2 max**

(ii)     (Between 06.00 and 12.00, (No Mark))

Respiration higher in soil under tree, (No mark)

*Do not mix and match mark points*

*No list rule*

1.      Tree roots carry out (a lot of) respiration;

2.      More / there are roots under tree;

*Accept converse for soil not under trees*

***OR***

3.      More food under trees;

4.      So more active / greater mass of / more organisms (carrying out respiration);

*Accept converse for soil not under trees*

***OR***

Soil not under trees respiration increases (No mark)

5.      Soil in sunlight gets warmer;

6.      Enzymes (of respiration) work faster;

*Accept converse for soil under trees*

**2 max**

(f)      (i)      1.      Photosynthesis produces sugars;

2.      Sugars moved to roots;

*Do not penalise named sugars other than sucrose*

3.      (Sugars) are used / required for respiration;

**2 max**

(ii)     Takes time to move sugars to roots;

*Look for movement idea in (i) – can carry forward to (ii)*

**1**

**[15]**

**M10.**(a)     Reverse transcriptase;

**1**

(b)     1.      Probe (base sequence) complementary (to DNA of allele A / where A is (and) binds by forming base pairs / hydrogen bonds;

*Accept gene A*

2.      So (only) this DNA labelled / has green dye / gives out (green) light;

*Accept glows for green light*

**2**

(c)     (i)      1.      More probe binding / more cDNA / mRNA / more allele / gene A means more light;

2.      DNA (with **A**) doubles each (PCR) cycle;

3.      So light (approximately) doubles / curve steepens more and more (each cycle) / curve goes up exponentially / increases even faster;

**3**

(ii)     (**G** because)

1.      (Heterozygous) only has half the amount of probe for **A** attaching / only half the amount of DNA / allele A (to bind to);

*Accept only one A to bind to*

2.      (So,) only produced (about) half the light / glow / intensity (of **H**) (per cycle of PCR);

*If reference to ‘half’ for point 1, allow ‘less light’ in 2.*

**2**

**[8]**

**M11.**(a)     (Formation of glycogen)

1.      Glucose concentration in cell / liver falls below that in blood (plasma) which creates / maintains glucose concentration / diffusion gradient;

2.      Glucose enters cell / leaves blood by facilitated diffusion / via carrier(protein) / channel (protein);

*Not just diffusion*

**2**

(b)     1.      Insulin sensitivity similar to / not (significantly) different from those with diabetes;

*No values for non-obese, so comparisons with ‘normal’ not possible*

2.      Overlap of SDs;

*Accept SE*

3.      Their sensitivity (to insulin also) improved by GBS;

**2 max**

(c)     1.      Sensitivity (to insulin) does increase;

*This part of the question concerns spread of data, not overlap of SDs*

2.      But large SD / large variation (after GBS);

*Accept use of figures / use of SD values to make this point.*

*Ignore ref to SE*

3.      (So) some showing no / little change / get worse;

4.      Do not know what sensitivity to insulin is of non-diabetics (who are not obese);

*Accept ‘normal’ as non-diabetic*

**3 max**

**[7]**

**M12.**(a)     1.      No / few consumers / pests / pathogens;

*Accept: No / few predators.*

*Accept: description of competition for a named resource with reference to ‘other species’.*

*Accept: More resistance to disease.*

2.      Outcompetes / better competitor for resources / light / CO2 / abiotic factor / ideal niche;

*Neutral: competition for food.*

**2**

(b)     1.      (Cost of) control / removal;

2.      (Cost of) restoring habitat / conservation;

3.      (Loss of income) from fishing;

4.      (Loss of income) from boating / tourism / recreation;

*Accept: any valid recreational activity e.g. canoeing.*

**2 max**

(c)     (i)      1.      Removes water;

2.      Water content can vary in sample / plant;

*Note: Reweighing / constant mass indicates all water removed = 2 marks. ;*

**2**

(ii)     1.      0.5 is not effective / has little effect / 1.0 is less effective (than 5.0) / concentrations below 5.0 less effective;

*Accept: for first 3 mark points effect on growth / biomass as a measure of effectiveness.*

*Accept: references to ‘this concentration’ = 5.0.*

*Accept: 5.0 is the minimum effective concentration.*

*1. and 2.      5.0 is the minimum effective concentration that reduces growth = 2 marks.*

2.      At 5.0 biomass / growth is reduced;

3.      Small difference between using 5.0 and 25.0;

4.      Using 5.0 is cost effective / using 25.0 is expensive / high concentrations may affect the environment / other organisms / chemical may remain in habitat / bioaccumulation;

*Accept: any impact on the habitat e.g. contaminate water supply.*

**4**

(d)     (i)      To compare / see effect with / without fungus / fluridone / control agent / s;

*Neutral: for comparison on its own.*

*Neutral: to see effect of variables / results / treatments / factors without further qualification.*

**1**

(ii)     1.      Is specific / grows / survives in Hydrilla / habitat;

*Accept: ‘known to work’*

2.      Can reproduce / only one application required;

3.      Does not become a pest;

**2**

(iii)    1.      Fluridone / chemical acts quickly / quickly reduces Hydrilla;

2.      Fungus / biological control keeps Hydrilla in low numbers / fungus / biological control works over a long time / can reproduce / resistance does not develop against fungus / biological control;

**2**

**[15]**

**M13.**(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]**

**M14.**(a)      PKNJ.

**1**

(b)     *Lutra lutra.*

**1**

(c)     Bone / skin / preserved remains / museums.

**1**

(d)     1.      (Hunting) reduced population size(s), so (much) only few alleles left;

*Accept bottleneck*

2.      Otters today from one / few surviving population(s);

*Accept founder effect*

3.      Inbreeding.

*Allow any* ***two***

**2 max**

(e)     1.      Population might have been very small / genetic bottleneck;

2.      Population might have started with small number of individuals / by one pregnant female / founder effect;

3.      Inbreeding.

*Allow any* ***two***

**2 max**

**[7]**

**M15.**(a)     (i)      1.      (Scientists) canߢt show bias / influence / may have a vested
          interest / work for the company developing the vaccine;

*Relates to the scientists*

2.      (Volunteers) can’t show psychological / mental effects / ‘placebo effect’ / expectations;

*Relates to the volunteers*

*Accept: reduces the ‘Hawthorne effect’ / demand characteristics*

*Neutral: so they have no idea what they are taking*

**2**

(ii)     Any **two** suitable suggestions, eg

*Neutral: refs. to age and health*

1.      Amount of nicotine in cigarettes;

*Neutral: different types of cigarette / different ways / frequency of smoking*

2.      Amount inhaled / absorbed / time since last cigarette;

*Neutral: absorption by gut / digestion*

*Accept: absorption by mouth*

3.      (Different) amounts excreted / metabolism / rate of binding (of nicotine) to protein;

*Accept: broken down (differently)*

4.      (Different) blood volumes;

*Neutral: different body masses*

5.      Nicotine from passive smoking / other smokers / other sources;

6.      Some volunteers received the vaccine / placebo;

*Accept: some volunteers would have / would not have the antibodies*

**2 max**

(b)     (i)      1.      Antibodies to nicotine produced / antibodies bind to nicotine;

***Q*** *Reject: vaccine contains / produces antibodies*

***Q*** *Neutral: antibodies digest / kill / fight nicotine*

2.      (So) nicotine does not bind to protein / does not reach the brain;

***Q*** *Reject: any reference to ‘active site’*

*Neutral: idea that the antibodies bind to the protein*

3.      (So) cigarettes / smoking does not satisfy addiction / reward smokers / release (reward) chemicals;

**3**

(ii)     **(Agree):**

1.      People choose to smoke / know the risks;

2.      Should spend this money on education / preventing people from starting to smoke / treating other health problems / vaccines are expensive;

**(Disagree):**

3.      Unethical not to treat;

4.      Less money needed to treat the effects of smoking / cancer / smokers pay taxes so are entitled to treatment;

**3 max**

(c)     1.      High antibody responders have a high % to stop smoking / are more likely to stop smoking;

*‘People producing a high concentration of antibodies’ is equivalent to ‘high antibody responders’*

*Accept: reference to values from the table*

2.      Only a few may be high antibody responders / no numbers on how many are high / medium / low antibody responders;

*Neutral: not all people are high antibody responders*

3.      Percentage who stopped smoking is similar for placebo group and low / medium responders / some / % of placebo group (still) stopped smoking / placebo has the lowest value / % to stop smoking;

*Accept: reference to values from the table*

4.      Large sample size / double blind **so** reliable / representative;

5.      Antibody levels peak at / drop after 5 months / boosters may be needed at / after 5 months;

6.      May start smoking again after 5 / 6 months / do not know the percentage who stopped smoking after 5 / 6 months;

7.      Nicotine is not the only factor responsible for making people smoke;

*Must mention nicotine*

*Do not accept: correlation does not mean causation / could be due to other factors*

**5 max**

**[15]**

**M16.**(a)     1.      Sugar-phosphate (backbone) / double stranded / helix **so** provides strength / stability / protects bases / protects hydrogen bonds;

*Must be a direct link / obvious to get the mark*

*Neutral: reference to histones*

2.      Long / large molecule **so** can store lots of information;

3.      Helix / coiled **so** compact;

*Accept: can store in a small amount of space for ‘compact’*

4.      Base sequence allows information to be stored / base sequence codes for amino acids / protein;

*Accept: base sequence allows transcription*

5.      Double stranded **so** replication can occur semi-conservatively / strands can act as templates / complementary base pairing / A-T and G-C so accurate replication / identical copies can be made;

6.      (Weak) hydrogen bonds **for** replication / unzipping / strand separation / many hydrogen bonds **so** stable / strong;

*Accept: 'H-bonds' for ‘hydrogen bonds’*

**6**

(b)     1.      (Mutation) in **E** produces highest risk / 1.78;

2.      (Mutation) in **D** produces next highest risk / 1.45;

3.      (Mutation) in **C** produces least risk / 1.30;

*Must be stated directly and not implied*

***E*** *>* ***D*** *>* ***C*** *= 3 marks*

*Accept: values of 0.78, 0.45 and 0.30 for MP1, MP2 and MP3 respectively*

*If no mark is awarded, a principle mark can be given for the idea that all mutant alleles increase the risk*

**3**

(c)     **180**;

**1**

(d)     **(Similarities):**

1.      Same / similar pattern / both decrease, stay the same then increase;

2.      Number of cells stays the same for same length of time;

*Ignore: wrong days stated*

**(Differences):**

(Per unit volume of blood)

3.      Greater / faster decrease in number of healthy cells / more healthy cells killed / healthy cells killed faster;

*Accept: converse for cancer cells*

*Accept: greater percentage decrease in number of cancer cells / greater proportion of cancer cells killed*

4.      Greater / faster increase in number of healthy cells / more healthy cells replaced / divide / healthy cells replaced / divide faster;

*Accept: converse for cancer cells*

*For* ***differences****, statements made must be comparative*

**3 max**

(e)     1.      More / too many healthy cells killed;

2.      (So) will take time to replace / increase in number;

*Neutral: will take time to ‘repair’*

3.      Person may die / have side effects;

**2 max**

**[15]**

**M17.**(a)      1.      To kill any fungus / bacteria on surface of seeds or in soil;

2.      So only the added fungus has any effect.

**2**

(b)     So that only nitrate or ammonia / type of fertiliser affects growth.

**1**

(c)     1.      So that effects of nitrate or ammonium alone could be seen;

2.      So that effects of fungus can be seen.

**2**

(d)     1.      Weigh samples at intervals during drying;

2.      To see if weighings became constant (by 3 days).

**2**

(e)     With live fungus – showing effects of the fungus:

1.      Fungus increases growth of roots and shoots in both;

2.      Produces greater growth with nitrate.

With heat-treated fungus – showing effects of fertiliser:

3.      Similar dry masses for roots and shoots;

4.      (Probably) no significant difference because SDs overlap.

**4**

(f)     1.      Dry mass measures / determines increase in biological / organic material;

2.      Water content varies.

**2**

(g)     1.      Fungus with nitrate-containing fertiliser gave largest shoot: root ratio;

2.      And largest dry mass of shoot;

3.      6.09:1 compared with ammonium-containing fertiliser 4.18:1

**2 max**

**[15]**

**M18.**(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]**

**M19.**(a)     1.      Draw grid over (map of) area;

2.      Select squares / coordinates at random.

**2**

(b)     1.      No emigration / immigration;

2.      No losses to predation;

3.      Marking does not affect survival;

4.      Birth rate and death rate equal;

5.      (In this case) all belong to one population.

**2 max**

(c)     1.      Only glows brightly with UV, so doesn’t make insects more visible;

2.      So doesn’t affect / increase predation;

***OR***

1.      Glows brightly with UV marking visible;

2.      So makes it easy to pick out labelled insects.

**2**

(d)     10 130.

Tolerance of ±1

 *= 1 marks*

**2**

(e)     1.      Scientists removed large numbers of insects (which were not returned) from same area / same population;

2.      Affecting ratio of marked to unmarked.

**2**

**[10]**

**M20.**(a)      1.      Kingdom, Phylum, Class, Order, Family;

2.      *Luscinia svecica.*

*1 mark for each correct column*

*Allow Genus and Species if both placed in box for species but not if both placed in genus box*

**2**

(b)     Number of different alleles of each gene.

*Accept number of different base sequences (found) in each gene*

**1**

(c)     1.      Has greater proportion of genes / percentage of genes showing diversity;

2.      Percentage is 35% compared with 28% / proportion is 0.35 compared with 0.28.

*Allow correct figures that are not rounded up, i.e., 34.9% / 0.349 and 27.8% / 0.278*

**2**

**[5]**

**M21.**(a)      Box around single nucleotide.

**1**

(b)

|  |  |  |
| --- | --- | --- |
|   | **DNA strand** | **Percentage of each base** |
|   | **A** | **C** | **G** | **T** |
|   | Strand **1** | (16) | **34** | **21** | **29** |
|   | Strand **2** | **29** | (21) | (34) | **16** |

2 rows correct = 2 marks;

1 row correct = 1 mark.

**2**

(c)     1.      Reference to DNA polymerase;

2.      (Which is) specific;

3.      Only complementary with / binds to 5’ end (of strand);

*Reject hydrogen bonds / base pairing*

4.      Shapes of 5’ end and 3’ end are different / description of how different.

**4**

**[7]**

**M22.**(a)     1.      Facilitated diffusion involves channel or carrier proteins whereas active transport only involves carrier proteins;

2.      Facilitated diffusion does not use ATP / is passive whereas active transport uses ATP;

3.      Facilitated diffusion takes place down a concentration gradient whereas active transport can occur against a concentration gradient.

*Since ‘contrast’, both sides of the differences needed*

**3**

(b)     3.3:1.

*Correct answer = 2 marks*

*If incorrect, allow 1 mark for 470–360 / 60 for rate in second hour*

**2**

(c)     1.      Group **A** – initial uptake slower because by diffusion (only);

2.      Group **A** – levels off because same concentrations inside cells and outside cells / reached equilibrium;

3.      Group **B** – uptake faster because by diffusion plus active transport;

4.      Group **B** fails to level off because uptake against gradient / no equilibrium to be reached;

5.      Group **B** – rate slows because few / fewer chloride ions in external solution / respiratory substrate used up.

**4 max**

**[9]**

**M23.**(a)     Species richness measures only number of (different) species / does not measure number of individuals.

**1**

(b)     Trees vary in height.

**1**

(c)     1.      Index for canopy is 3.73;

2.      Index for understorey is 3.30;

3.      Index in canopy is 1.13 times bigger;

*If either or both indices incorrect, allow correct calculation from student’s values.*

**3**

(d)     1.      For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;

2.      For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;

3.      Because P < 0.001 which is highly significant / is much lower than 5%.

**3**

**[8]**

**M24.**(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]**

**M25.**(a)      1.     Trachea and bronchi and bronchioles;

2.      Down pressure gradient;

3.      Down diffusion gradient;

4.      Across alveolar epithelium.

*Capillary wall neutral*

5.      Across capillary endothelium / epithelium.

**4 max**

(b)     (About) 80.0%.

**1**

(c)     1.      (Group **B** because) breathe out as quickly as healthy / have similar FEV to group **A**;

2.      So bronchioles not affected;

3.      FVC reduced / total volume breathed out reduced.

*Allow this marking point for group* ***C***

**3**

**[8]**

**M26.**(a)     **Two** suitable suggestions;

E.g.

1.      (Are mammals so) likely to have same physiology / reactions as humans;

2.      Small enough to keep in laboratory / produce enough milk to extract;

3.      (Can use a) large number.

*Ignore references to ethical issues*

**2 max**

(b)     1.      Hydrolysis of lipids produces fatty acids;

2.      Which lower pH of mixture.

**2**

(c)     1.      (Bile-activated lipase / it) increases growth rate (of kittens);

2.      Results for formula with lipase not (significantly) different from breast milk / are (significantly) different from formula milk alone;

3.      Showing addition of (bile-activated) lipase is the likely cause (of increased growth);

4.      Lipase increases rate of digestion of lipids / absorption of fatty acids.

**3 max**

**[7]**

**M27.**(a)     Any **two** of the following:

Concentration of enzyme

Volume of substrate solution

pH.

*Allow same concentration of substrate*

**1**

(b)     Ratio between 5.18:1 and 5.2:1

Initial rates incorrect but correctly used = 1 mark.

*Allow 1 mark if rate at:*

*60°C = 0.83g dm–3 s–1 /49.8g dm–3 minute–1*

***OR***

*37°C = 0.16g dm–3 s–1 /9.6g dm–3 minute–1*

**2**

(c)     At 60 °C:

1.      More kinetic energy;

2.      More E–S complexes formed.

*Allow converse for 37 °C*

**2**

(d)     Different times:

1.      Higher temperature / 60 °C causes denaturation of all of enzyme;

*Accept converse for 37 °C*

2.      Reaction stops (sooner) because shape of active site changed;

*Reject if active site on substrate*

Different concentrations of product (at 60 °C)

3.      Substrate still available (when enzyme denatured);

4.      But not converted to product.

**4**

**[9]**

**E1.**(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.

**E3.**(a)     Almost all students appreciated what was meant by ‘insulin-dependent’.

(b)     Although the wording used by many students did not entirely match that of the Marking Guidelines, there was often a good understanding of the scientific principles demonstrated to support the assessments made.

(c)     It was appropriate to consider exercise as equivalent to movement. The majority of students appreciated that such was based on respiration and that respiration uses glucose.

(d)     In written papers, students often struggle with calculations. However, in this case, the majority produced an answer that fell within the stipulated range.

(e)     It was pleasing to see that most students gave both sides of the story to give differences between the two methods. It was not appropriate to give credit where this was not the case. Many students were able to make full use of the resource material and obtain full marks for this question.

(f)     This part proved to be more challenging for many students although some excellent accounts were seen. A synthesis of ideas from the resource material was the key in this question as opposed to lifting relevant aspects for comparison with the previous part, a skill that was more demanding and reflected by the mark range seen.

**E4.**This question was targeted at grade E. It is again surprising that all parts proved to be good discriminators.

(a)     Two-thirds of students gained full marks. This was usually for mentioning that organisms of the same species can produce fertile offspring. However, some students failed to gain the mark for replacing the word ‘fertile’ with ‘viable’.

(b)     (i)      Seventy percent of students correctly calculated the index of diversity within the range of 6.97 to 7. Of the other thirty percent, most gained one mark for calculating a correct numerator or denominator.

(ii)     Nearly all students gained at least one mark, typically for ‘fewer habitats’. Similarly, reference to pesticides or machinery decreasing species diversity was common. Compared with the previous series, it was pleasing to see a greater percentage of students refer to ‘less food sources’ or ‘less variety of food’, rather than simply ‘less food’. Relatively few students linked clearing the forest to a reduction in the number of plant species.

**E5.**Students did not score highly on this question. They often failed to interpret the question and use the data appropriately. Few students quoted correct figures and many failed to realise that the figures for stomach cancer and heart disease showed little difference. Many wrote in terms of contracting the disease rather than dying from it, as referred to in the resource. Others vaguely referred to ‘certain diseases’ and therefore failed to gain credit. In many cases, students simply repeated answers they had learned from past papers. These answers often gained one mark for referring to the idea that other factors are involved.

**E6.**(a)     This proved to be a good discriminator. Half of students gained at least two marks and a wide range of incorrect answers were seen. However, it was evident that many students did not know that proteins contain nitrogen or that polymers are formed by condensation reactions.

(b)     Most students gave the correct answer of **16**.

(c)     Many students were aware that fetal haemoglobin has a higher affinity for oxygen than adult haemoglobin. However, the ability to link this to partial pressure of oxygen discriminated well. Very few students directly stated that oxygen moves from mother to foetus.

(d)     Many students were aware that adult haemoglobin has a lower affinity for oxygen. However, the ability to link this to respiring cells, tissues or muscles proved to be a good discriminator.

(e)     It was disappointing that only a quarter of students gained this mark. Many simply repeated the question stem and stated that ‘adult haemoglobin is also produced’. Only the best responses conveyed the idea of ‘enough’, or that the curves are similar.

**E7.**(a)     This was generally answered well. Some references to error bars without mention of representing standard deviation were seen, and these answers were not given credit for mark point 2.

(b)     This was generally answered well. There were some inappropriate uses of grids and coordinates and some trees shaken or beaten to remove leaves; neither method was credited.

(c)     The vast majority of students pointed out that there was no overlap of standard deviations (or 2 × the standard deviation) for mark point 3 but did not go any further to gain the second mark. Although the range was calculated correctly by many for mark point 4, very few correctly identified that it was not possible to draw a conclusion without a statistical test result. Many students referred to standard error without appreciating that this had not been given and could not be worked out without knowing the sample size.

(d)     This question provided an opportunity for students to shine and express their understanding correctly in the context of the information provided. Many answers were seen, however, relating to sun leaves being warmer and therefore having more enzyme activity to produce chlorophyll. These were in the wrong context and did not gain the marks.

**E8.**Parts (a), (b) and (c)(i) proved to be good discriminators.

(a)     60% of students scored at least two marks. This was usually for appreciating that water and blood flow in opposite directions to maintain a concentration or diffusion gradient. However, relatively few students mentioned that this occurs along the whole length of the gill. Those who scored zero often gave an account of how the gills are adapted for efficient gas exchange, or did not convey the importance of *maintaining* a concentration or diffusion gradient. There were also some lengthy descriptions of ventilation in fish. It should be noted that this topic is not included in the specification content for BIOL2.

(b)     70% of students scored full marks for linking thicker lamellae to a greater diffusion distance and the fusion of lamellae to a reduced surface area. However, some failed to pick up a second mark due to a lack of precision; for example, ‘less diffusion occurs’ and ‘the diffusion pathway is thicker’.

(c)    (i)      A third of students obtained the correct answer of **5.14** and scored both marks outright. However, many students obtained the principle mark for showing 90 × 0.4 or 90 ÷ 7 in their method.

(ii)     Very few students obtained the marks by suggesting that an increase in the temperature of the water would increase the fish’s metabolism, or rate of respiration, or cause less oxygen to dissolve in the water. The majority of students referred to an increase in kinetic energy, or that water molecules would be moving faster.

**E9.**(a)    About three quarters of students obtained both marks for the calculation in this part. Some students only scored one mark because of incorrect rounding of numbers in their calculations or answers.

(b)     This part proved far more challenging than intended. It was hoped that students would note that only (plants and) non-photosynthetic soil organisms are mentioned in the study and point out that there are lots of other organisms / animals that are not mentioned. The examiners accepted statements that carbon dioxide from leaves did not take into account effects of photosynthesis, because students were not told until (d) that measurements were taken in the dark. Quite a few students treated the leaves of plants and the stems and roots of plants as separate organisms, rather than different parts of the same organisms. Nearly three quarters of students failed to score any marks.

(c)     To obtain two marks in this part, students had to identify three measurements: volume of carbon dioxide, from a given / known area, in a set time. If they identified two of these, they obtained one mark. A quarter of students obtained two marks and about half failed to score. There were many vague references to *amount* of carbon dioxide and *time* unqualified and many students missed out area altogether.

(d)     This part was done well by many students and three quarters obtained both marks. They were able to state that there is no photosynthesis in the dark and photosynthesis would take up carbon dioxide. Some students were confused about whether it was photosynthesis or respiration that produces carbon dioxide, or uses it.

(e)    (i)       Most students noted that respiration in soil under trees is always higher in this part. Over a third went on to describe a difference in the peak times of respiration in soil under trees and soil not under trees. Although a 2 mm grid was not given on the graph, the examiners expected some attempt to describe time frames, rather than just *earlier* or *later*.

(ii)     Correct answers to this part usually revolved around respiration in soil not under trees increasing because the soil gets warmer in sunshine and this leads to faster enzyme activity. Very few looked back to the table and noted the high rate of respiration in roots of plants, of which there would be a lot under trees. Many students thought that photosynthesis by the trees would make more oxygen available in the soil under the trees. Others thought that photosynthesis by the soil not under the trees would increase during the day.

(f)      As the final interpretive question on the final paper, this part was intended to be challenging and so it proved. Very few students appear to appreciate the relationship between photosynthesis and respiration in plants in terms of respiratory substrate. This was tested last year and proved challenging then. Students should appreciate that plants make their own respiratory substrates via photosynthesis. Those students who did score in this part did understand this. Given that many students treated leaves and roots of plants as separate organisms in (b), it was perhaps not surprising that very few students suggested it takes time for sugars to travel from leaves to roots. Some got ‘close’ by suggesting it took time for oxygen from photosynthesis to travel to the roots.

**E10.**(a)    About 80% of students identified the enzyme in this part as reverse transcriptase. The commonest wrong answer appeared to be restriction endonuclease.

(b)     Most students obtained one mark for stating that the DNA probe has a base sequence complementary to the DNA of allele A. A third obtained a second mark by going on to state that this allowed it to bind to the target DNA by base pairing, or that this meant only target DNA gives off green light.

(c)    (i)       About half of students obtained one mark in this part for noting that the more probe binding to allele A, the more green light there would be. Nearly a quarter obtained a second mark, usually for also noting that the light curve goes up exponentially (or described). Only a few, 14%, obtained all three marks. These students explained that this was because the amount of DNA doubles (approximately) with each PCR cycle.

(ii)     Answers to this part often made references to G being heterozygous because this person had *fewer* A alleles and thus *less* light was produced. The examiners were looking for more precise statements relating to half the amount of A with probe attached and half (approximately) the light produced (at any given time). A third of students obtained both marks.

**E11.**(a)    80% of students failed to score. Most repeated the stem of the question and wrote that formation of glycogen leads to a lowering of blood glucose. Others drifted into explanations of the mode of action of insulin and the role of the pancreas. The examiners were looking for the idea that formation of glycogen lowers the concentration of glucose in liver cells below that in the blood. As a result, there is a diffusion / concentration gradient for the entry of glucose into liver cells (from the blood).

(b)     Students scored much better on this part. Most noted that the insulin sensitivity was similar in both groups of patients. Some backed this up with observations about overlap of standard deviations. Again, the examiners accepted standard errors here but it should not be assumed that this applies in all cases. About 40% of students got both marks and a similar percentage got one mark.

(c)     It was heartening in this part to see many students using knowledge of standard deviations to answer this question correctly. Nearly 40% obtained all three marks and these students all included statements about the large standard deviations of the means after surgery and how these showed that some patients’ sensitivity to insulin did not increase after surgery. In this context, the examiners ignored references to standard errors, since it was the spread of data about the mean(s) that was important.

**E12.**(a)    Many students appreciated that Hydrilla was a better competitor, although the factor being competed for was often not specified. Similarly, a number of students stated that Hydrilla would not be eaten to a great extent in its environment. Relatively few students provided both ideas in their responses. Often, students would give two examples where Hydrilla was the better competitor. The consumption of the plant was very frequently described as predation. A significant number of students thought there was competition for food, even though Hydrilla was identified as an aquatic plant. Weaker responses merely stated that it was better adapted or could grow / reproduce / photosynthesise faster. Some students clearly thought Hydrilla was an animal despite information to the contrary. It was also suggested that Hydrilla had introduced a disease that killed the native plants, hence removing any competition.

(b)     This question proved to be relatively straightforward for most students who often gained at least one of the two marks. Most appreciated that controlling Hydrilla would have financial implications. References to loss of income from reduced tourism, fishing and recreational activities were also common but only two out of every five students gained both marks. It was also common for students to simply refer to reduced species diversity or more competition with crops.

(c)    (i)      The majority of students gained at least one mark, usually for explaining that the method would remove water. Fewer students mentioned that the water content could vary in different samples. Some students did link a constant mass to all the water being removed for two marks. Vague answers about repeats for reliable / accurate results or to identify anomalies were fairly common.

(ii)     This question produced a good spread of marks with most students scoring at least two marks. These were often gained for identifying that the recommended concentration reduced growth and that higher concentrations of fluridone could damage other organisms. The expense of using higher concentrations was also a very accessible mark. Over 25% of students gained all four marks, usually by also including a reference to the relative ineffectiveness of lower concentration of the chemical. Very few students highlighted that the highest concentrations of fluridone used did not produce a significant decrease in growth compared to the recommended concentration.

(d)    (i)      Less than two out of five students gained this mark by providing specific details on why the scientists carried out the control experiment. Most students simply stated that a comparison could be made without mentioning the chemical or fungus. Similarly, unqualified references to the effect of variables or treatments were not credited.

(ii)     Most students obtained one mark by stating that the fungus would be specific or ‘it is known’ to work. Unfortunately, many students then described the general advantages of biological control rather than the advantages of using this particular fungus.

(iii)    Correct answers usually included the fast action of fluridone, the fungus maintaining the Hydrilla at low numbers or that resistance does not develop against the fungus. However, many students only provided one of these and the majority simply referred to the general advantages of integrated pest control. These answers did not always link the specific effectiveness of each type of control agent and consequently did not always gain credit. Nevertheless, there were some excellent responses and over 50% of students gained at least one mark.

**E13.**(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.

**E15.**Parts (a)(ii), (b)(i), (b)(ii) and (c) proved to be good discriminators.

(a)    (i)      Nearly all students scored one mark and this was usually for suggesting that this method prevented the scientists from being biased. Unfortunately, the second suggestion provided by some also related to the scientists, rather than the volunteers; for example, ‘they may have a vested interest’. Students who scored a second mark often referred to reducing the placebo effect or psychological effects.

(ii)     One-third of students scored full marks. The most common mark points awarded were for suggesting that different types of cigarette contain different amounts of nicotine, different amounts may be absorbed, different amounts may be excreted and that the volunteers may have different blood volumes. Unfortunately, a lack of precision let down some students; for example, ‘they smoked different cigarettes’ and ‘they had different body masses’.

(b)    (i)      Just over half of students scored at least two marks. This was usually for mentioning that nicotine will not bind to the protein, so the smoker will not feel rewarded. Surprisingly, few students clearly expressed the idea that the vaccine stimulates the production of antibodies to nicotine, or that these antibodies bind to nicotine. A common misconception seen in weaker responses was that the vaccine *contains* antibodies to nicotine. Similarly, some students thought that *this* vaccine contained a weakened strain of bacteria. Generally, there were three incorrect approaches to this question, which were all due to not reading the introduction carefully enough. The first was that the vaccine *causes* the release of reward chemicals, meaning that a person would not need to smoke. The second was that the vaccine stops smokers from feeling addicted, rather than stopping them from feeling rewarded. The third was that the antibodies to nicotine bind to the protein in the brain, instead of to nicotine. Unfortunately, some students had the second mark disqualified for referring to the protein receptor in the brain as an enzyme. A minority also thought that the ability of the vaccine to stop people smoking could be spread within the population to other smokers by herd immunity.

(ii)     Just under half of students scored at least two marks. The most common mark points awarded were for appreciating that people choose to smoke, the vaccine would be expensive and less money would be needed to treat the effects of smoking. Relatively few referred to it being unethical not to treat smokers, or that money would be better spent in preventing people from smoking. Students who failed to score often gave vague responses; for example, ‘if it is free, more people will stop smoking’ and ‘it will prevent people from dying of cancer’. A minority suggested that the vaccine should not be used at all, due to the Government losing millions of pounds each year in tax on cigarettes. Some of the weakest responses did not answer the question set. These typically contained stock How Science Works phrases such as, ‘it is only one study’ and ‘we do not know the sample size’.

(c)     It was disappointing that only one-fifth of students scored at least three marks. Again, weaker responses often contained stock How Science Works phrases, which did not apply specifically to this investigation. The question clearly asked students to *use the data* to evaluate the statement made by the journalist. This said, many students did note that high antibody responders are more likely to stop smoking. Many also realised that the placebo group and low antibody responders had a similar percentage of volunteers who stopped smoking. The next most accessible mark point was that the volunteers may start smoking again after five or six months. Better responses also noted the peak, or drop, in the concentration of antibodies. However, some failed to mention when this occurred, or quoted an incorrect time from the graph. Relatively few students suggested that only a small proportion of the population may be high antibody responders, or that the large sample size produced more reliable or representative results. Overall, it was evident that many students did not analyse the data in the graph and table in enough detail, particularly in relation to the timing of events.

**E16.**Parts (a), (b) and (d) proved to be good discriminators.

(a)     It was disappointing that only just below 40% of students scored at least half marks. This was mainly due to simply describing the structure of DNA, without explaining how these features relate to its functions. Some students wrote about DNA structure and function in different paragraphs. This made it unclear which feature went with which function, as no direct links had been made. In contrast, there were some truly excellent responses, which had clearly been well planned before putting pen to paper. The most common mark points awarded were for the sugar-phosphate backbone providing strength or protecting bases, the helix allowing the molecule to be compact, weak hydrogen bonds allowing strand separation or replication and the two strands acting as templates or allowing semi-conservative replication. Relatively few students linked complementary base pairing with accurate replication or the production of identical copies of DNA. Similarly, few students referred to DNA as a large molecule that can store lots of information, or the base sequence coding for amino acids. Weaker responses often mentioned this in the context of the genetic code being degenerate. Indeed, some students thought that the base sequence causes amino acids to be *produced*. The ability to convey that *many* hydrogen bonds provide stability was rarely seen. It was also unfortunate that a number of students wasted their time by writing about irrelevant topics such as the differences between prokaryotic and eukaryotic DNA and the role of histones. There were also some lengthy accounts of DNA replication, enzyme structure and the different levels of protein structure.

(b)     Many students scored at least two marks for stating that a mutation in gene **E** produces the highest risk and a mutation in gene **C** produces the lowest risk. However, only the best responses also referred to gene **D**. Students who did not mention any of the genes usually picked up one mark for noting that all of the mutant alleles increase the risk of lung cancer. Surprisingly, some thought that a mutation in gene **D** produces the highest risk.

(c)     Just fewer than 40% of students gave the correct answer of **180**.

(d)     Two-thirds of students scored at least two marks. Many were able to identify the decrease, plateau and increase for healthy cells and cancer cells. However, relatively few made reference to the plateau occurring for the same length of time. Students who failed to gain a mark for a similarity usually ignored the plateau. Most students spotted that a greater number of healthy cells were killed or that they experienced a faster decrease in number. Similarly, it was impressive to see that some used data from the graph to calculate that a greater *proportion* of cancer cells were killed. Many students also noted the faster increase in the number of healthy cells.

(e)     Half of students scored full marks. This was usually for mentioning that too many healthy cells would be killed, which could kill the patient or cause side effects. However, relatively few appreciated that it would take time to replace the healthy cells that had been killed.