Questions

Q1.

Forests are important habitats.

The effect of cutting down trees on the number of bird species observed in two different forest habitats was investigated.

(i) Give two biotic factors, other than cutting down trees, that could affect the number of bird species observed in a forest.

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(ii) Some of the results of the investigation are shown in the table.

Forest	Number of bird species in areas of the forest where no trees are cut down	Number of bird species in areas of the forest where some trees are cut down
A	35	19
B	16	10

Calculate the Chi-squared value (χ^2) for forest B using the formula shown.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

(3)

Answer ....

(iii) The table gives some critical values for the Chi-squared test.

Probability level	Critical value
0.05	3.84
0.01	6.64
0.001	10.83

The Chi-squared value for forest A is 4.74.
Deduce the effect of some trees being cut down on the number of species of birds in these two forests.

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(Total for question = 7 marks)

Q2.

The earthworm, (*Lumbricus terrestris*), feeds on dead organic matter found in soil.

Soil pH is one of the abiotic factors that affects the population size of earthworms.

The populations of earthworms in fields with either acidic soil or alkaline soil have been investigated.

The results of this investigation are summarised in the table.

Sample	Earthworms in field with acidic soil		Earthworms in field with alkaline soil	
	Number per square metre	Mass per square metre / g m^{-2}	Number per square metre	Mass per square metre / g m^{-2}
1	80	184	723	1 164
2	59	110	1 613	1 968
3	106	253	354	439
4	31	70	728	961
5	121	238	214	233
6	75	139	874	1 739
7	97	149	668	1 096
8	138	309	121	213
9	63	95	791	1 455
10	63	84	497	736
Total	833	1 631	6 583	10 004

Deduce the effect of pH on the number and mass of earthworms in these two types of soil.

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(Total for question = 4 marks)

Q3.

The earthworm, (*Lumbricus terrestris*), feeds on dead organic matter found in soil.

Soil pH is one of the abiotic factors that affects the population size of earthworms.

The populations of earthworms in fields with either acidic soil or alkaline soil have been investigated.

The results of this investigation are summarised in the table.

Sample	Earthworms in field with acidic soil		Earthworms in field with alkaline soil	
	Number per square metre	Mass per square metre / g m^{-2}	Number per square metre	Mass per square metre / g m^{-2}
1	80	184	723	1164
2	59	110	1613	1968
3	106	253	354	439
4	31	70	728	961
5	121	238	214	233
6	75	139	874	1739
7	97	149	668	1096
8	138	309	121	213
9	63	95	791	1455
10	63	84	497	736
Total	833	1631	6583	10004

Describe a sampling method that could be used to collect the data in this table.

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(Total for question = 4 marks)

Q4.

The banded snail *Cepaea nemoralis* occupies many habitats.

The thrush is a major predator of the banded snail.

The thrush and the banded snail, shown in the photograph, occupy different niches.

Source: © Dave Watts/Alamy

Describe the difference between the terms niche and habitat.

(2)

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(Total for question = 2 marks)

Q5.

Photosynthesis contributes to the productivity of ecosystems.

(i) State what is meant by the term ecosystem.

(1)

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(ii) The table shows information about two types of ecosystem.

Ecosystem	Gross productivity / g m^{-2} day^{-1}	Net productivity / g m^{-2} day^{-1}	Percentage of gross productivity used in respiration (%)	Total surface area of Earth occupied / km^2
Tropical rainforest	16.7	5.5	67.1	510 x 10^6
Salt marsh	10.5		34.3	5.5 x 10^4

Calculate the net productivity of the salt marsh ecosystem.

(2)

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(iii) Comment on the impact of these different types of ecosystem on global warming.

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(Total for question = 6 marks)

Q6.

The earthworm, (*Lumbricus terrestris*), feeds on dead organic matter found in soil.

Soil pH is one of the abiotic factors that affects the population size of earthworms.

The populations of earthworms in fields with either acidic soil or alkaline soil have been investigated.

The results of this investigation are summarised in the table.

Sample	Earthworms in field with acidic soil		Earthworms in field with alkaline soil	
	Number per square metre	Mass per square metre / g m⁻²	Number per square metre	Mass per square metre / g m⁻²
1	80	184	723	1 164
2	59	110	1613	1 968
3	106	253	354	439
4	31	70	728	961
5	121	238	214	233
6	75	139	874	1 739
7	97	149	668	1 096
8	138	309	121	213
9	63	95	791	1 455
10	63	84	497	736
Total	833	1 631	6 583	10 004

Explain how differences between the mass of earthworms in these two soils could be shown to be statistically significant.

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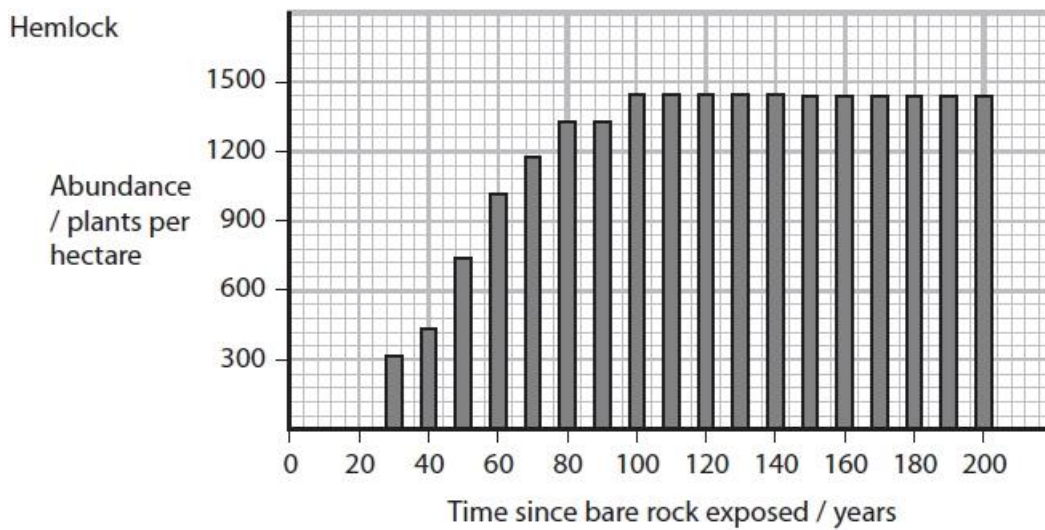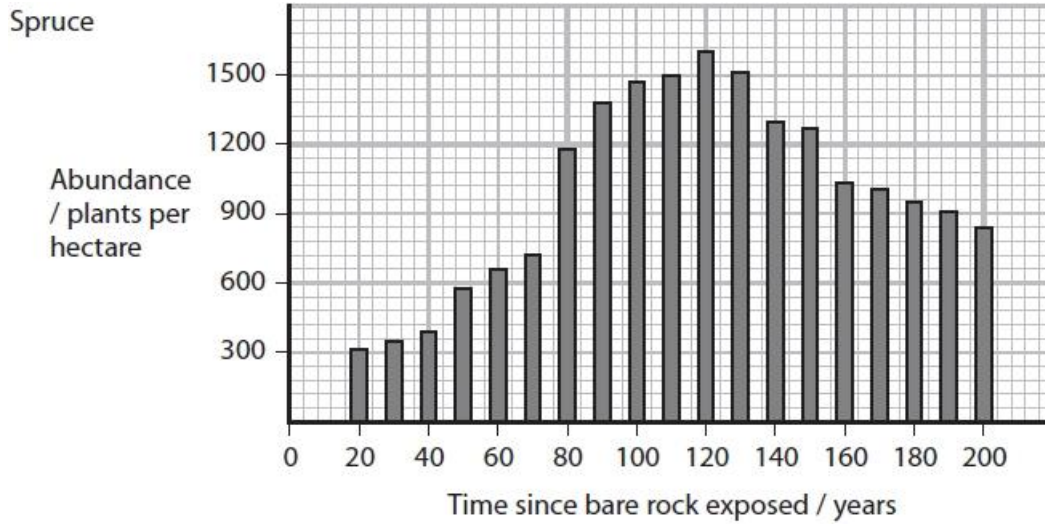
(Total for question = 3 marks)

Q7.

The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.

Front edge of glacier in 1985

Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

The graphs show the abundance of three species of tree since the bare rock was exposed as the glacier retreated. The abundance of each species was measured every ten years for 200 years.

Spruce

Abundance / plants per hectare vs Time since bare rock exposed / years

Hemlock

Abundance / plants per hectare vs Time since bare rock exposed / years
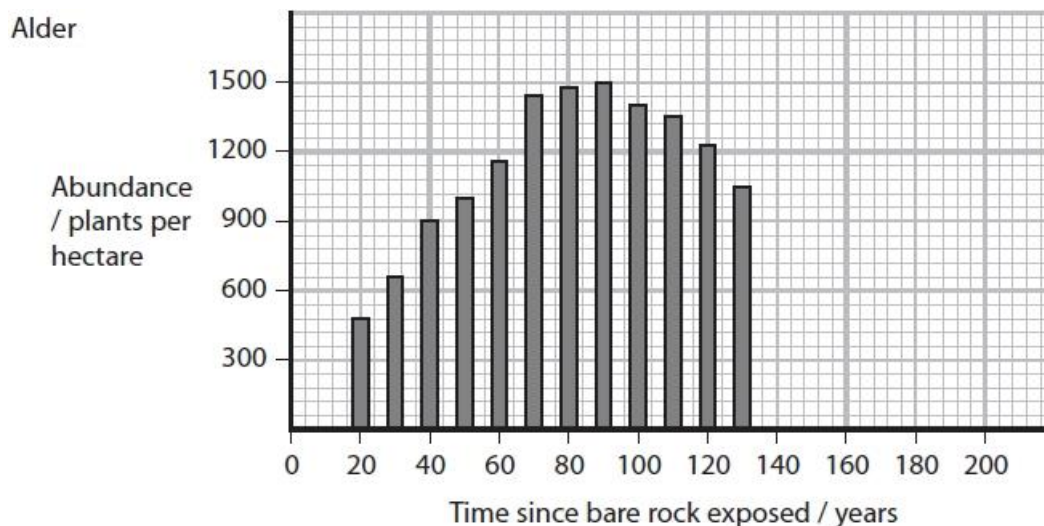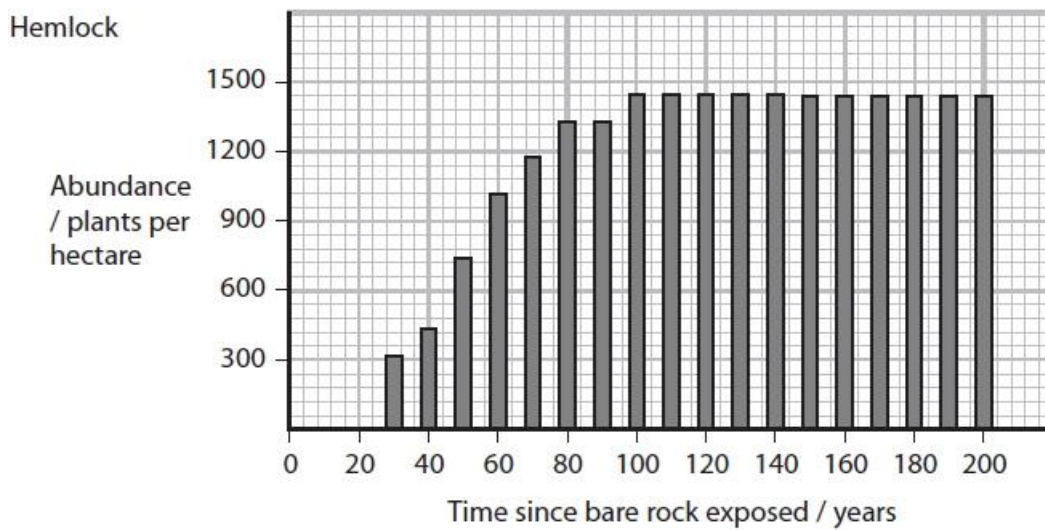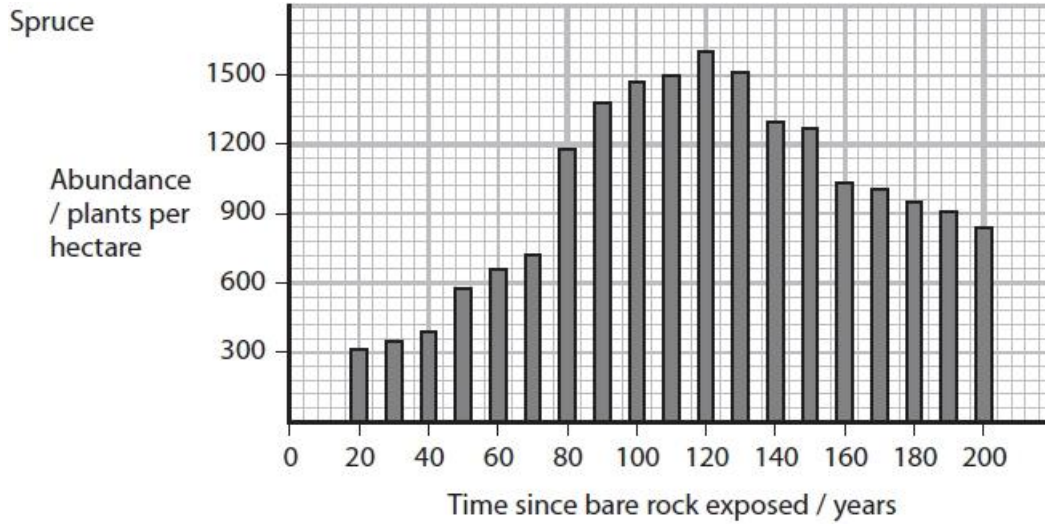
Comment on the changes in the abundance of these three species over 200 years.

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(Total for question = 4 marks)

Q8.

The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.

Front edge of glacier in 1985

Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

The graphs show the abundance of three species of tree since the bare rock was exposed as the glacier retreated. The abundance of each species was measured every ten years for 200 years.

Spruce

Hemlock
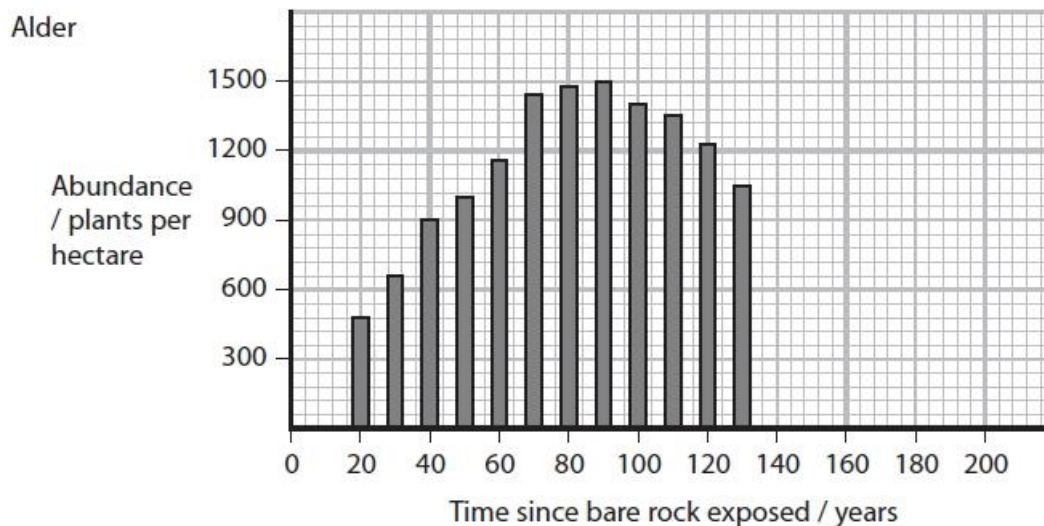
Explain what happened to the bare rock to allow the growth of these trees.

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(Total for question = 3 marks)

Q9.

Hymenoscyphus fraxineus (*H. fraxineus*) is the fungus that causes ash dieback.
This disease usually kills all the ash trees that it infects.

The diagrams show the distribution of ash trees and *H. fraxineus* in 2007.
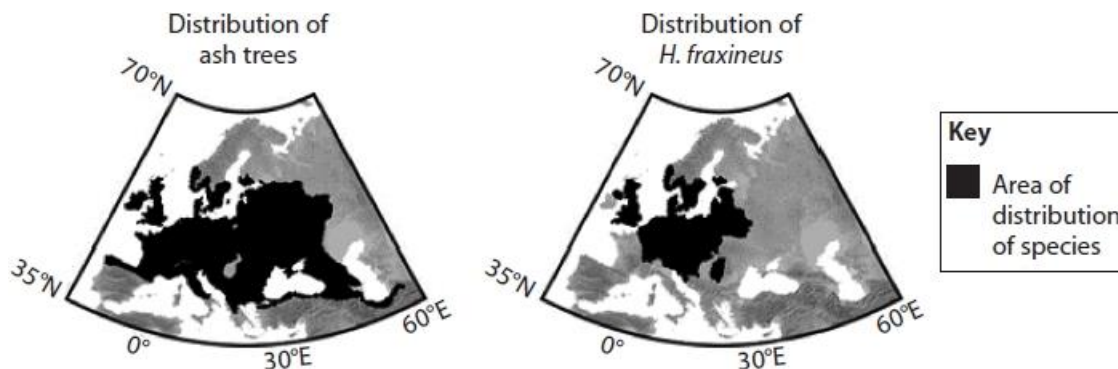
In 2007 the mean atmospheric carbon dioxide concentration was 398 ppm.

Models have been used to predict the effect of increasing atmospheric carbon dioxide concentration on the distribution of ash trees and *H. fraxineus*.

The table shows these predictions.

Concentration CO$_2$ / ppm	Predicted region suitable for ash trees	Predicted region suitable for *H. fraxineus*	Predicted distribution of ash trees
430			
1080			

(i) Which of the following is an abiotic factor that should be considered in the model?

(1)

☒ **A** ash tree resistance to *H. fraxineus*

☒ **B** *H. fraxineus* pathogens

☒ **C** humidity

☒ **D** ocean pH

(ii) Which of the following could be caused by an increase in atmospheric carbon dioxide from 398 ppm to 1080 ppm?

(1)

☒ **A**   decreased photosynthesis

☒ **B**   global warming

☒ **C**   increased plant respiration

☒ **D**   ozone depletion

(iii) Analyse the data to explain the predicted effect of climate change on the distribution of ash trees.

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(Total for question = 7 marks)

Q10.

The coffee husks, shown in the photograph, are a waste product of coffee plantations. Composting has been suggested as an environmentally friendly way of decomposing these coffee husks.

The effect of adding cow dung to coffee husks, before they are composted, has been investigated.

The table shows the percentages of organic carbon and nitrogen in two compost heaps at the start of composting and after 90 days.

	Husks alone		Husks with added cow dung	
Days composting	0	90	0	90
Organic carbon (%)	54.50	41.70	48.10	35.40
Nitrogen (%)	1.84	2.31	2.76	3.19

* The changes in the compost heaps are due to the activity of decomposers and other organisms.

Devise an investigation to determine the effect of the carbon to nitrogen ratio on the succession of species in these compost heaps.

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(Total for question = 6 marks)

Q11.

There are two main types of woodland in the UK. One consists of broadleaved deciduous trees, the other contains coniferous trees that have needle-like leaves.

In a study of two woodlands, 11 species of plant were found in a deciduous woodland and 4 different species in a coniferous woodland.

The table shows the other data recorded in this study.

Factor	Deciduous woodland	Coniferous woodland
Mean light intensity 10 cm above soil level / lux	1075	543
Mean pH of soil	7	5
Mean air temperature 10 cm above soil level / °C	18	18
Mean soil moisture content (%)	45	47

Assess the reasons for the differences in the number of species between these two types of woodland.

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(Total for question = 4 marks)

Q12.

The photograph shows a glacier at the top of a mountain.
Glaciers in many areas of the world are retreating (reducing in size).
The line on the photograph shows the position of the front edge of the glacier in 1985.

Front edge of glacier in 1985

Bare rock is exposed as the glacier retreats. Two hundred years ago, bare rock was exposed after a glacier retreated. A study has been made of the long-term changes in vegetation on that area of rock after the retreat of the glacier.

Plants such as lupin are often found in the early stages of glacial retreat. Lupin plants have nodules on their roots containing nitrogen-fixing bacteria that convert atmospheric nitrogen to ammonium ions. Plants can use ammonium ions as a source of nitrogen.

Explain why lupin plants are able to grow in the early stages of glacial retreat.

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(Total for question = 3 marks)

Q13.

The pigment content of mountain plants can be affected by various environmental factors. These factors include altitude (height up a mountain), exposure to ultraviolet radiation (UV-B) and temperature.

These pigments include chlorophyll, found in chloroplasts, and flavonoids that are found in sap vacuoles.

Flavonoids can protect plants from ultraviolet radiation (UV-B) that can damage DNA.

The altitude at which a plant grows on a mountain affects its flavonoid content.

Devise a procedure to show that an increase in altitude increases the flavonoid content of one species of plant found growing on a mountain.

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(Total for question = 5 marks)

Q14.

The pigment content of mountain plants can be affected by various environmental factors. These factors include altitude (height up a mountain), exposure to ultraviolet radiation (UV-B) and temperature.

These pigments include chlorophyll, found in chloroplasts, and flavonoids that are found in sap vacuoles.

Flavonoids can protect plants from ultraviolet radiation (UV-B) that can damage DNA.

Scientists have investigated the effect of UV-B on both chlorophyll and flavonoid content.

A group of plants was exposed to UV-B for 20 minutes per day for one month. The chlorophyll and flavonoid content of each plant were then determined and the means calculated.

This was repeated for three more groups of plants. Each group was exposed to UV-B for different lengths of time. All other variables were kept constant.

The results are shown in the table.

Length of time exposed to UV-B / minutes	Mean chlorophyll content / arbitrary units	Mean flavonoid content / arbitrary units
0	32	25
20	30	24
40	27	39
60	24	40

(i) Compare and contrast the effect of length of exposure to UV-B on the chlorophyll and flavonoid content of these plants.

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(ii) As altitude increases on a mountain, the temperature decreases and the UV-B radiation increases.

Scientists have found that a rise in temperature decreases flavonoid gene expression in plants.
Analyse the data to discuss why altitude can affect plant growth.

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(Total for question = 8 marks)

Q15.

Global warming can affect abiotic factors that determine the distribution of organisms.

The presence of sodium chloride in soil is an abiotic factor that affects the germination of seeds.

The effects of sodium chloride solution and gibberellin on the germination of rice seeds have been investigated.

Gibberellin regulates developmental processes in plants.

Fifty seeds were placed in each of three Petri dishes containing different solutions.

The seeds were incubated for 96 hours and the number that germinated in each Petri dish was counted.

Treatment	Solution	Number of seeds germinating
Control	Distilled water	48
Sodium chloride	120 mmol dm^{-3} of sodium chloride	33
Sodium chloride and gibberellin	120 mmol dm^{-3} sodium chloride and 50 µmol dm^{-3} gibberellin	45

(i) Give a null hypothesis for this experiment.

(1)

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(ii) Calculate the chi-squared (X^2) value for these results, using the formula provided.

(3)

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Answer ....

(iii) In a second experiment, using the same three treatments, the chi-squared (X^2) value was found to be 6.635.

The table gives the critical values for the chi-squared (X^2) test at different probability levels.

Degrees of freedom	Probability level		
	0.05	0.01	0.001
1	3.841	6.635	10.83
2	5.991	9.210	13.82
3	7.815	11.34	16.27
4	9.488	13.28	18.47

Deduce the statistical significance of the results of the second experiment.

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to two of the following: • food availability (1) • interspecific competition (1) • predation (1) • disease (1)	IGNORE time of year / availability of resources ALLOW grazing / migration IGNORE competition unqualified or competition between birds	Choose an item. (2)

Question number	Answer	Additional guidance	Mark
(ii)	• correct expected value (1) • correct values for observed minus expected squared (1) • correct answer (1)	$26 \div 2 = 13$ $(16 - 13)^2 = 9$ and $(10 - 13)^2 = 9$ 1.38 ECF for incorrect expected value ALLOW one mark for 2.25 / 3.6	Choose an item. (3)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: • cutting down trees decreases the number of bird species in both forests (1) • the decrease is significant (at p=0.05) in forest A (1) • the decrease was not significant (at p=0.05) in forest B (1)	ALLOW decreases species richness ALLOW less than {5% / 0.05 probability}reduction in forest A due to chance ALLOW more than than {5% / 0.05 probability} reduction in forest B due to chance ALLOW 1 mark chi squared value was {greater than the critical value for forest A / less than critical value for forest B} with no reference to p value or significance	Choose an item. (2)

Q2.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to four of the following: • in alkaline soil the number of worms is greater (1) • in alkaline soil the (total) mass of worms is greater (1) • in alkaline soil the mass of individual earthworms is less (1) • earthworms reproduce more in alkaline soil (1) • in alkaline soil earthworms are smaller due to greater competition (for resources) (1)	ALLOW mean mass of ALLOW converse arguments for each point ALLOW higher pH for alkaline soil an earthworm is 1.96g in acidic soil and 1.52g in alkaline soil	**(4)**

Q3.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to four of the following: • (record) a named relevant variable factor associated with the soil (1) • use of quadrats of stated area (1) • detail of random sampling within the areas (1) • standardised method for collecting earthworms (1) • recording the number and the mass of the earthworms in each quadrat (1)	e.g. temperature, humidity, soil water content, soil type, humus content e.g. one square metre, $0.5m^2$ e.g. random co-ordinates IGNORE transects e.g. digging to the same depth, same time frame ALLOW 'count and weigh' earthworms	**(4)**

Q4.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: • niche is the way an organism interacts with its environment (1) • habitat is the place (with distinct set of conditions) where an {organism lives / community of organisms live} (1)	ALLOW niche is the role an organism plays in its {habitat / environment / where it lives} ALLOW the {environment / place} where organisms live	(2)

Q5.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following: • organisms and {non-living components / abiotic factors} (1)		(1)

Question number	Answer	Additional guidance	Mark
(ii)	Choose an item. • correct value for respiration (1) • respiration value calculated subtracted from gross productivity value (1)	Example of calculation $10.5 \times (34.3 \div 100) = 3.6$ $10.5 - 3.6 = 6.9$ (g m^{-2} day^{-1}) Correct answer with no working gains full marks	(2)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to three of the following: • tropical rain forests use a greater percentage (of gross productivity) in respiration (1) • tropical rain forests occupy a larger surface area (1) • therefore (tropical rain forests) release more carbon dioxide (1) • which is a greenhouse gas / making a greater contribution to global warming (1)	ALLOW converse arguments for salt marsh for mps 1, 2 and 3	**(3)**

Q6.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following: • find mean values (1) • use a t-test/ calculate a t-value (1) • (calculated) t-value needs to be greater than the critical value (1) • (compared to cv for) probability of { 0.05 / 5% } (1)	ALLOW use of mean values IGNORE chi-squared test ALLOW compare the t-value to the critical value	**(3)**

Q7.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following • succession has occurred (1) • alder and spruce were the first species of tree to colonise (1) • slowest increase in abundance was spruce (1) • (interspecific) competition occurs between the three species (1) • example of resources competed for (1)	 IGNORE primary or secondary ALLOW either alder or spruce ALLOW description of increase and decrease of abundance of each species over time ALLOW spruce and hemlock compete with alder / hemlock competes with spruce and alder e.g. water, mineral ions, light, etc.	 (4)

Q8.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • the bare rock was colonised by pioneer species (1) • (these pioneer species) break up the rock (1) • dead plants add {humus / organic matter} (as they decompose) (1) • (eventually trees will be able to grow) as the soil {becomes deeper / can retain more water } (1)	 ALLOW algae or lichen	 (3)

Q9.

Question Number	Answer	Mark
(i)	C – humidity The only correct answer is **C** **A** is not correct because resistance to infection is a biotic factor **B** is not correct because pathogens are biotic factors **D** is not correct because ocean pH is an abiotic factor but not one relevant to plants and their pathogens	(1)

Question Number	Answer	Mark
(ii)	**B** – global warming The only correct answer is **B** **A** is not correct because increase CO_2 to 1080 ppm does not decrease photosynthesis **C** is not correct because increased CO_2 to 1080 ppm does not increase plant respiration **D** is not correct because increased CO_2 to 1080 ppm does not cause ozone depletion	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following • carbon dioxide (is a greenhouse gas and) causes global warming • a relevant description of a change in the distribution of ash trees (with increasing CO_2 concentrations) • (because increased CO_2) would result in a change in the range for *H. fraxineus* (1) • and ash trees will be found in regions without *H. fraxineus* • change in range of { *H. fraxineus* / ash trees } linked to a relevant aspect of climate change	 e.g. an increase to 430 ppm leads to more ash trees in the east or an increase to 1080 ppm leads to more ash trees in the north e.g. temperature increase, change in humidity, change in rainfall patterns	(5)

Q10.

Question Number	Answer
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • standardisation of composition of compost heaps • identification of species • abundance of each species of organism in the sample • determination of C:N / set up compost heaps with different C:N ratios • time e.g. days / intervals / repetition of sampling • other factors to monitor or control e.g. water / gases / humidity / temperature / aeration / mass • sampling technique e.g. location of sample within compost heap / repetition of sampling

Level	Mark	Descriptor	
0	Marks	No awardable content	
Level 1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Measure / set up compost heaps with different C:N ratios Observe species present over time
Level 2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Recording species present / numbers of each species / measuring C:N ratio Monitoring changes over time Control of relevant factors
Level 3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Description of a suitable sampling technique Linking species present or species density to C:N measurements Use of a statistical test to compare changes of time / C:N ratio Use information on numbers of species and population sizes to demonstrate succession

Q11.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following points • (difference in number of species) not due to temperature and soil moisture content as they are the {same/similar} in the two woodlands (1) • the light intensity is the most likely reason for the greater number of species as it is higher in the deciduous woodland (1) • description of the effect of light intensity on plant growth (1) • the pH of the soil in the coniferous woodland is acidic so this may also reduce the number of species found (1) • only plant species considered and not other organisms (1)	e.g. high light intensity allows a greater rate of photosynthesis / more photosynthesis or plants need to be adapted to low light intensities	(4)

Q12.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following • (in the early stages of glacial retreat) the soil may lack nitrates (1) • (however) lupin plants can use the { ammonium ions / source of nitrogen } produced by the bacteria (1) • (therefore can) synthesise { amino acids / chlorophyll / nucleic acids / nitrogenous bases } (1)	ALLOW other sources of nitrogen lacking ALLOW produce for synthesise ALLOW protein	(3)

Q13.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to five of the following:		
	• variable {heights / altitude} **(1)**		
	• {collecting / growing} plants for each sample **(1)**	ALLOW reference to plant material in place of plants	
	• standardising plant material to be analysed **(1)**	e.g. same mass / same part of plant	
	• other abiotic factors taken into account **(1)**	e.g. humidity, wind speed, soil moisture, soil pH	
	• method of extraction of pigment **(1)**	e.g. use of solvent	
	• method to measure pigment **(1)**	e.g. use of colorimeter	**(5)**

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: Similarities: • exposure to UV-B for 20 mins decreases both (mean chlorophyll and flavonoid content) **(1)** Differences: • (longer than 20 min) exposure to UV-B causes chlorophyll to decrease and flavonoid to increase **(1)** • greater change in flavonoid content **(1)**		**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to five the following: • higher altitude more flavonoids synthesised **(1)** • DNA protected from UV-B **(1)** • reduced risk of mutations (so more growth) **(1)** • reduced chlorophyll (due to more UV-B) **(1)** • reduced photosynthesis (so less growth) **(1)** • reduced enzyme activity (so less growth) **(1)**	ALLOW converse statements ALLOW greater expression of the flavonoid gene at higher altitude	**(5)**

Q15.

Question number	Answer	Additional guidance	Mark
(i)	An answer that makes reference to the following: • treatment of seeds with sodium chloride or sodium chloride and gibberellin has no effect on the number of seeds that germinate (1)		**(1)**

Question number	Answer	Additional guidance	Mark
(ii)	Choose an item. • correct expected value calculated (1) • $(O – E)^2$ values calculated (1) • Sum of $(O – E)^2$ values divided by expected value (1)	Example of calculation: = 42 36, 81 and 9 126 ÷ 42 = 3 ALLOW calculations based on E value of 48 or 50 <table><tr><td>Obs</td><td>Exp</td><td>$(O - E)^2$</td><td>$(O - E)^2/E$</td></tr><tr><td>48</td><td>**42**</td><td>**36**</td><td>0.857143</td></tr><tr><td>33</td><td>42</td><td>**81**</td><td>1.928571</td></tr><tr><td>45</td><td>42</td><td>**9**</td><td>0.214286</td></tr><tr><td></td><td></td><td></td><td>**3**</td></tr><tr><td>48</td><td>**50**</td><td>**4**</td><td>0.08</td></tr><tr><td>33</td><td>50</td><td>**289**</td><td>5.78</td></tr><tr><td>45</td><td>50</td><td>**25**</td><td>0.5</td></tr><tr><td></td><td></td><td></td><td>**6.36**</td></tr><tr><td>48</td><td>**48**</td><td>**0**</td><td>0</td></tr><tr><td>33</td><td>48</td><td>**225**</td><td>4.6875</td></tr><tr><td>45</td><td>48</td><td>**9**</td><td>0.1875</td></tr><tr><td></td><td></td><td></td><td>**4.875**</td></tr></table> Correct answer with no working gains full marks	(3)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to the following: • calculated value is significant at p = 0.05 (1) • at 2 degrees of freedom (1)		(2)