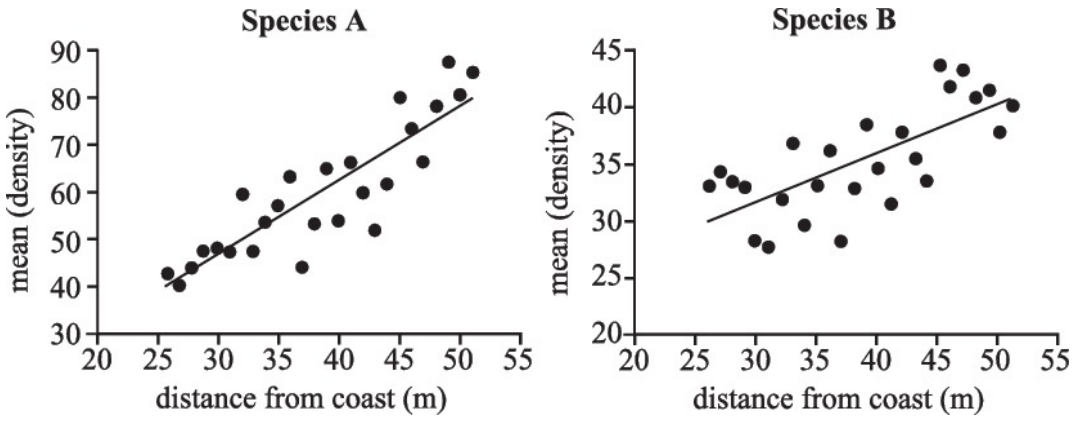
Answer **all** the questions.

1. The graphs below show the density of two different plant species as proximity to the coast changes.



Which of the following statements correctly describes one aspect of the technique used to collect these data?

A Quadrats were randomly placed using a random number generator and coordinates.
B Larger quadrats were required for **species A** because their mean density was higher.
C A belt transect has been used to allow calculation of density.
D Abiotic factors were measured at every point of quadrat sampling.

Your answer ☐

[1]

2. Deep sea vents on the ocean floor are surrounded by unusual organisms such as chemosynthetic bacteria and eyeless shrimp.

Which of the following statement(s) about these ecosystems is / are true?

Statement 1: The temperature of the vents influences the organisms that live there.

Statement 2: A predatory octopus would affect the balance of these organisms.

Statement 3: The number of eyeless shrimp found at each vent is constant.

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐

[1]

3. This question is about ecosystems in the Southern (Antarctic) Ocean.

Observe the food chain:

phytoplankton (producers) → krill (shrimps etc.) → small fish → large fish → seals

Table 21.1 shows the transfers of energy and the quantities of energy stored as biomasses for the food chain. Magnitudes are given in kilojoules per square metre of sea surface per year.

	Phyto-plankton	**Krill**	**Small fish**	**Large fish**	**Seals**
Energy input, by photosynthesis or feeding ($kJ\ m^{-2}\ y^{-1}$)	900	80	11	1.4	
Energy lost to surroundings by respiration ($kJ\ m^{-2}\ y^{-1}$)	180	64	8.8	1.2	1.05
Energy input converted to biomass ($kJ\ m^{-2}\ y^{-1}$)	720	16	2.2	0.2	0.05
Biomass energy lost to other consumers or decomposers ($kJ\ m^{-2}\ y^{-1}$)	640	5	0.8	0.09	0.05

Table 21.1

(i) For larger and less numerous organisms, such as the seal, it is more appropriate to record energy flows per square kilometre.

Calculate the energy input to the seal population from large fish. Record your answer in kilojoules per square **kilometre** of sea surface per year.

Answer_____ **[2]**

(ii) Calculate the percentage of energy stored in large fish biomass converted to energy in seal biomass. Show your working.

Answer_____ **[2]**

4(a). A small, permanent pond is the habitat for a climax community of producers (aquatic plants and algae) and consumers (bacteria, protoctista, worms, snails, arthropods and small vertebrates like newts and fish).

Why might ecologists call this a 'climax community'?

[1]

(b). The protoctist *Paramecium caudatum* is usually between 200 and 300 μm in length. An accurate measurement would help in the correct identification of a specimen from this pond.

What laboratory equipment would you select to make an accurate measurement of the length of *Paramecium caudatum*?

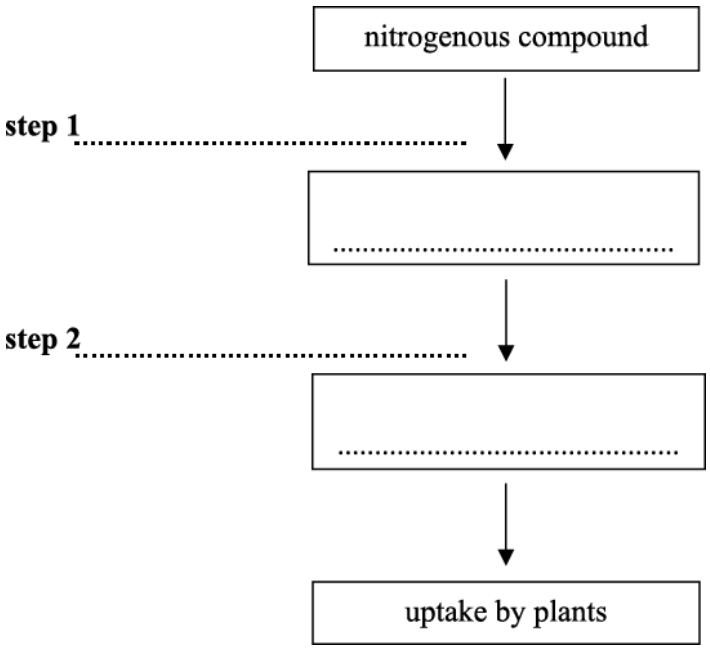
[2]

(c). An animal fell into the pond. It drowned and decayed. Within a year the biological compounds in its body had been completely recycled.

(i) What nitrogenous excretory molecule from the decomposers would pass to the next stage of the nitrogen cycle?

[1]

(ii) Complete the flow chart to show what happens to this nitrogenous compound, and name the groups of bacteria involved at steps 1 and 2, as it is converted to a form that plants can take up and use.



[4]

5(a). Explain how the selective breeding that led to this increased yield could have been done.

[4]

(b). State **two** developments, other than selective breeding, that could account for the total increase in wheat yield per hectare.

1

2

[2]

6(a). The elk, *Cervus canadensis*, is a large herbivore.

Fig. 2.1, shows figures relating to the number of elk in Yellowstone National Park in the USA between 1965 and 2002.

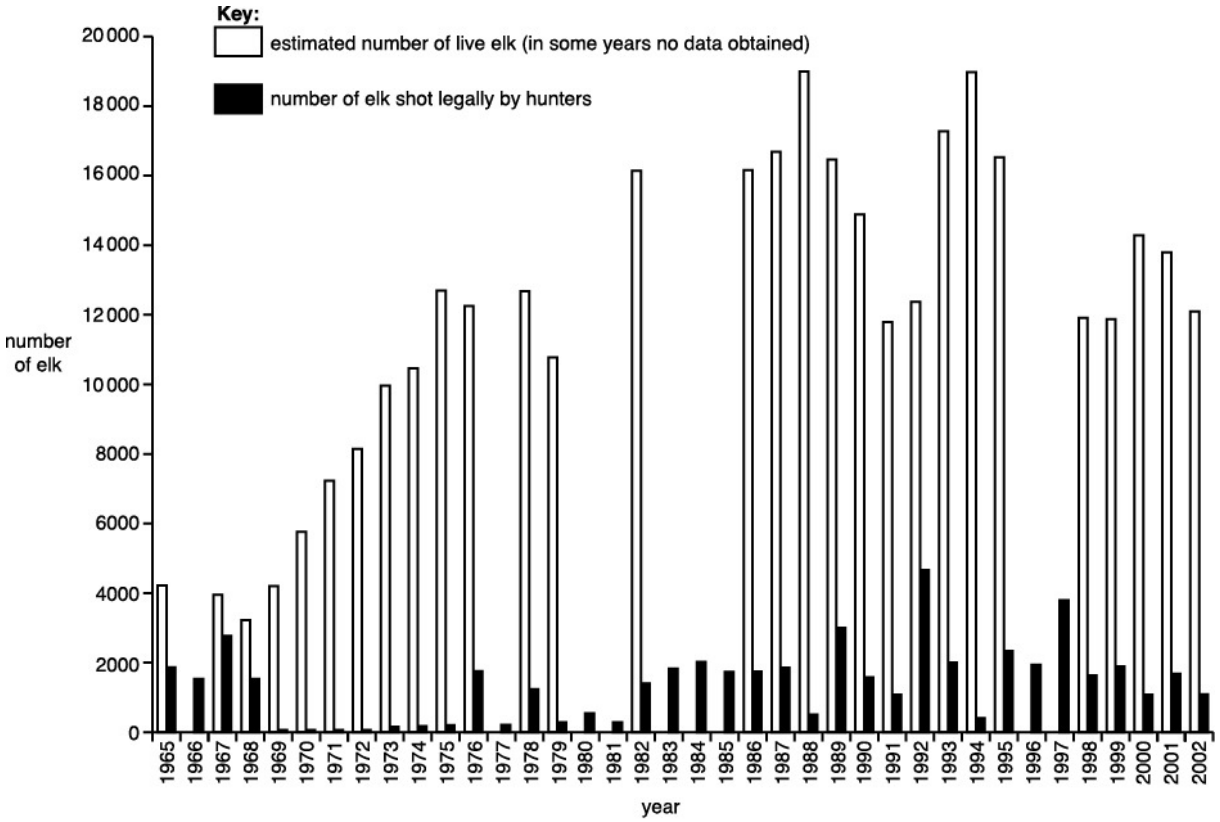


Fig. 2.1

The figures were obtained in two different ways:

- the white bars show estimated numbers of live elk obtained by ecological sampling
- the black bars show numbers of elk that were legally shot by hunters.

In some years no data for live elk were obtained.

(i) Using Fig. 2.1, describe the pattern shown by the data for the estimated number of live elk from 1965 to 2002.

---**[3]**

(ii) The recorded number of elk legally shot by hunters provides accurate data.

Suggest why these data are accurate, but the method used to obtain these data is not a valid way of estimating the number of elk in the population.

---**[2]**

(b). The grey wolf, *Canis lupus*, is a large predator whose diet includes elk.

By 1926, grey wolves had been hunted to extinction in Yellowstone Park. However, this species could still be found in other parts of the world.

In 1995, a population of grey wolves was introduced to Yellowstone Park and their numbers increased.

(i) With reference to Fig. 2.1, discuss the factors that may have affected the size of the elk population:

- before 1995
- after 1995.

In your answer you should provide a balanced account referring to factors before and after 1995.

---

[7]

(ii) Explain why the introduction of wolves to Yellowstone Park in 1995 is an example of conservation.

[2]

7(a). The efficiency of energy transfer between trophic levels limits the number of organisms in a particular ecosystem.

Outline how the **percentage efficiency** of energy transfer between producers and herbivores can be estimated.

---

[4]

(b). One way that humans try to maximise food production is to manipulate the transfer of energy through ecosystems.

A number of methods can be used to increase energy transfer through agricultural ecosystems and other food production systems.

These methods include:

A	artificial selection
B	recombinant DNA technology
C	growing microorganisms in a fermenter
D	use of immobilised enzymes
E	control of plant physiology with synthetic plant hormones
F	manipulation of the nitrogen cycle.

Using the letters **A** – **F**, select the **most suitable** method that could be used to achieve each of the aims shown in the table below.

You may select each letter more than once.

Aim	**Letter**
improving soil that is low in nutrients for the growing of wheat	
preventing the spoilage of fruits after picking	
reducing the impact of a fungal disease on yields from cucumber plants	
producing strawberry plants that grow quicker and fruit earlier	
making sugar syrup from waste starch	
producing large amounts of a fungus for food	

[6]

8(a). Describe the differences between the following biological terms:

a pioneer community and a climax community

---**[2]**

(b). decomposition and denitrification

---**[2]**

(c). nitrogen fixation and nitrification

---**[2]**

9. The list below describes some types of plant found during primary succession on a sand dune.

i. a legume that contains nitrogen fixing bacteria
ii. hardy grasses that can resist desiccation
iii. large mature trees
iv. small herbs that can tolerate salty spray
v. small trees and bushes

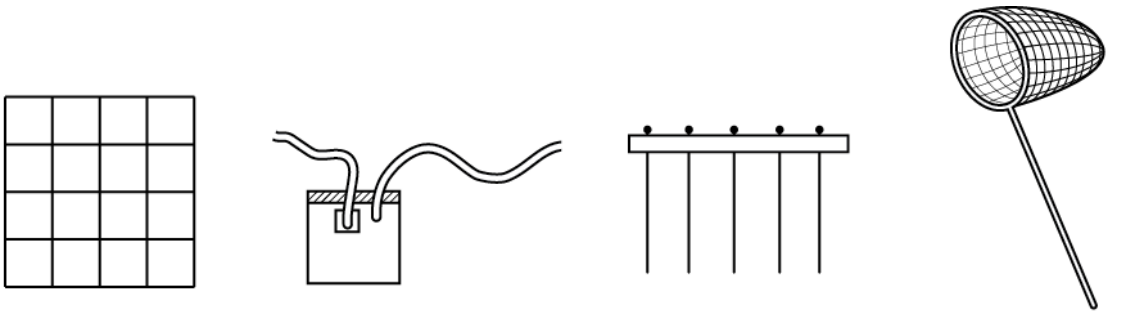
In which order are these plants most likely to grow successfully?

A i – ii – iii – iv – v
B ii – v – iv – i – iii
C ii – iv – i – v – iii
D ii – iv – iii – v – i

Your answer

[1]

10. The images show four pieces of apparatus that could be used to collect data about biodiversity in the field.



frame quadrant **P**

pooter **Q**

point quadrant **R**

sweep net **S**

Which row, **A** to **D**, describes when each piece of apparatus would be used to measure species evenness and richness in a meadow?

Row	Measuring species richness	Measuring species evenness
A	Q, S	R
B	P	P, R
C	P, Q, R, S	P, Q, R, S
D	P, Q, R, S	P, Q, S

Your answer

[1]

11(a). A student investigated the distribution of buttercups (*Ranunculus bulbosus*) in a field which contained a pond. The student noticed that the buttercups near the pond looked slightly different from those further away. After further investigation the student identified the buttercups near the pond as a different species (*Ranunculus repens*).

(i) Describe how the student would use a belt transect to investigate the distribution of the two buttercup species.

[3]

(ii) Use the space below to show the format of a results table suitable for recording the results of the student's investigation. (You do not need to include any suggested data.)

[2]

(b). As the ground dipped towards the pond the soil became obviously wetter. The student thought that the soil moisture might affect the distribution of the two buttercup species.

Suggest **one** biotic factor that might affect the distribution of the buttercups.

---

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2			B	1	
			Total	**1**	
3		i	110 000 / 1.1×10^5 (1) kJ km^{-2} y^{-1} (1)	2	**ALLOW** the word or any reasonable symbol for year **ALLOW** kJ y^{-1} km^{-2}
		ii	25 (1)(1)	2	**ALLOW** correct answer in the working if the answer line is left blank. If answer is incorrect, **award 1 mark** for $0.05 \div 0.2 \times 100$
			Total	**4**	
4	a		(pond community is) final / stable / not subject to further succession	1	**IGNORE** 'permanent', it is in the rubric.
	b		light microscope (1) graticule (1)	2	
	c	i	urea / uric acid	1	**ALLOW** ammonia, ammonium (ions).
		ii	Nitrosomonas (1) nitrite (1) Nitrobacter (1) nitrate (1)	4	
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
5	a		1 crossbreed / breed / interbreed, high-yielding, wheat plants / individuals; 2 <u>assess / test / measure</u>, yield / AW; 3 crossbreed / AW, selected / best / high-yielding, offspring; 4 over generations 5 marker assisted selection / prevent self-pollination / genetic screening / prevent unwanted (cross) pollination;	4 max	**1 ACCEPT** breed high-yielding individuals **1 ACCEPT** 'mate / reproduce' as AW for 'breed' **1 IGNORE** inbreed **1 ACCEPT** description of high-yielding plant, e.g. more, ears / grain / seed / wheat **1 ACCEPT** if only one of the plants is high-yielding **2 IGNORE** select the best offspring **4 ACCEPT** several / a few generations **4 IGNORE** time **5 ACCEPT** descriptions **5 IGNORE** the ones with the correct gene **5 ACCEPT** prevent self-fertilization **Examiner's Comments** The topic of selective breeding is frequently tested as it falls within two separate learning outcomes. Despite this, or perhaps because of this, many candidates gave a generic answer, gaining two or three marks but rarely four. Only candidates who related their answers to the example in the question gained full marks. A number of candidates failed to appreciate 'high yield' as the desired characteristic. Some just referred to 'tall plants' or, resistance to disease. References to measuring yield in the offspring or further detail relating to plant breeding were rarely seen. Some candidates seemed unaware that plants are able to carry out sexual reproduction and responses from such candidates were limited to one mark for a reference to many generations.

Question			Answer/Indicative content	Marks	Guidance
	b			2 max	**IGNORE** prompt lines and mark as prose **IGNORE** refs to climate change
			(use of) fertiliser;		**IGNORE** crop rotation **IGNORE** increase in soil minerals **IGNORE** irrigation
			(use of) pesticide / fungicide / insecticide;		**ACCEPT** selective herbicide **IGNORE** decrease in pests
			improved technology;		**ACCEPT** e.g. better harvesting technology **IGNORE** genetic modification / irrigation **Examiner's Comments** It was pleasing to see many candidates gaining both marks. Of those that didn't it was commonly for making vague references to 'better farming' or 'more soil minerals'. Many cited GM technology, not appreciating that it's development was too recent or that such crops are currently banned in the UK.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
6	a	i	**1** peak in, 1988 / 1994; **2** trend decrease after 1994; **3** ref. decrease and then increase, 1988 to 1994; **4** fluctuations (within pattern); **5** overall increase from 1965 to 2002;	3 max	**IGNORE** ref to population figures **1 ACCEPT** increases until / highest number in, 1988/1994 **4 ACCEPT** 'goes up and down' / oscillates **Examiner's Comments** This question was generally well answered. The majority of candidates were able to identify either or both of the peaks in 1988 and 1994 and some went onto mention the decrease and increase in population between these dates, finishing with the decrease after 1994. It was encouraging to see general statements about the fluctuations in the data and the overall increase from 1965 to 2002. Common errors were to describe trends from 1965 to 1988 or comment on the numbers of shot elk. Other mistakes made were misreading the data or not mentioning any dates at all.

Question			Answer/Indicative content	Marks	Guidance
		ii	*accurate because* *idea that* actual number of elk shot is recorded; *method not valid because idea that* number of elk shot / hunting success, varies independently of population size;	2	**ACCEPT** elks shot are counted / reported **CREDIT** suitable reason e.g. numbers of licences issued / number of hunters set quotas to hunt illegal hunting if weather suitable for hunting only younger / older / diseased / larger, elk killed **IGNORE** length of time spent hunting **Examiner's Comments** Most candidates got the first marking point and understood that the number of elk shot would be recorded and was therefore accurate. However, fewer candidates gained the second marking point about why the method was not valid. The candidates who did get it tended to talk about illegal hunting making the data less valid, as opposed to hunting success being independent of overall population size. A common mistake was to talk about hunting scaring off elk from the area or elk dying from factors other than hunting. Some candidates also confused their answers by talking about ecological sampling in general and not relating it to the question asked.

Question			Answer/Indicative content	Marks	Guidance
	b	i	**1** *idea that population size is determined by* limiting factor(s); *Before 1995, population increases due to* **2** example of factor that is not limiting population; *Before 1995, population levels off because* **3** reaches carrying capacity; *Before 1995, population becomes limited by* ***4*** intraspecific competition for named resource; **5** interspecific competition for named resource; *Population can decline at any time/ dips, due to* **6** severe weather / natural disaster; **7** decrease before 1995 not due to wolves (as none present); **8** decrease after 1995 (probably) due to wolves; **9** *idea that* effect of wolves on population may be debatable;	6 max	**IGNORE ref to abiotic / biotic factors throughout** **2** e.g. plenty of, enough, food Less / no predation Less / no overcrowding/ enough space less hunting **2 IGNORE** water / nutrients / availability of food **4 CREDIT** description of intraspecific **5 CREDIT** description of interspecific **4 & 5 CREDIT** any suitable limiting factor eg competition for, food / space / mates / overcrowding **6 CREDIT** ref to parasites / disease / drought / floods / fires **9** e.g. lack of data in 1996 and 1997 makes it difficult to from conclusions

Question			Answer/Indicative content	Marks	Guidance
		i	QWC;	1	**Award if** **1 mark** awarded from **mps 1 to 6 (limiting factors)** **and** **1 mark** awarded from **mps 7 to 9 (effect of wolves)** **Examiner's Comments** Most students used additional sheets for this question but very few gained additional marks for their extra effort. Mostly they continued with lengthy descriptions and explanations of predator-prey relationships and gained no marks for that. Those candidates who recognised the need to explain the population growth curve and did so in a logical sequence, setting out a section for before 1995 and one for after 1995, gained the most marks for this question. Very few candidates recognised that limiting factors were involved. A good number of candidates recognised that the population increase was due to an abundance of food, enough space, enough mates or less predation or less hunting. Some candidates didn't mention the population at all or mentioned the size of the elk, and not the elk population. General references to population being affected wouldn't gain marks here as it was specifically for a reason linking it to an increase in population. A minority of candidates mentioned the carrying capacity being reached before 1995 but sometimes it was not always awarded due to it being referred to after 1995. When candidates used the proper terms of intraspecific and interspecific competition or described them correctly they often missed the marks by not giving a **named** resource or linking it with population size, rather than a named resource. Many candidates gained the mark for

Question			Answer/Indicative content	Marks	Guidance
					disease affecting population size but sometimes didn't link it with a decrease or dip in population size. The link that any decrease before 1995 was not due to the wolves as none were present was rarely awarded, but the majority of candidates mentioned that after 1995 there was a decrease in elk population and it was likely due to the wolves. This often triggered the QWC mark being awarded. Very occasionally candidates mentioned the idea that the effect of wolves on population may be debatable. There were a number of candidates who wrote about Elm trees or Elk trees and not Elk. In some cases, candidates went into detail of photosynthesis and mineral ions in the soil, showing a complete misunderstanding of the question asked, and relating it to a question asked about Elm trees in a previous paper.

Question			Answer/Indicative content	Marks	Guidance
		ii	*re-introduction of wolves is conservation because* 1 restoring the ecosystem (to its original form) **or** maintains biodiversity; 2 helps the (global) wolf population; 3 active / dynamic / sustainable, management / maintenance; 4 prevents over-population by the elk; 5 prevents over-grazing **or** damage to, habitat / ecosystem;	2 max	**ACCEPT** controls/ increases, biodiversity **ACCEPT** wolves do not become extinct / increase in number 'Actively maintains biodiversity' = **MP1 and 3** **ACCEPT** wolves, limit / control, elk population or lack of wolves causes elk population to grow **ACCEPT** if wolves absent, elk would damage habitat / other species may become extinct **Examiner's Comments** This was generally a well answered question with references to maintaining or increasing biodiversity and the idea of conserving the wolf as a species, gaining two marks. Only a few answers included reference to biological control of the elk population, which if uncontrolled would result in damage to the ecosystem by overgrazing. A lack of key terms (ecosystem / management / maintenance) stopped some candidates from getting both marks and several candidates used the word 'conservation' in their answer, despite it being in the stem of the question. Common mistakes were to focus the whole answer on just increasing biodiversity or helping the wolf population, without making a second point for the other mark, or to give a general definition of conservation without relating it to the question asked.
			Total	**14**	

Question			Answer/Indicative content	Marks	Guidance
7	a		1 $\frac{\text{herbivore / primary consumer,energy}}{\text{producer energy}}$ x 100 ;	4 max	**1 CREDIT** $\frac{\text{trophic level 2 energy}}{\text{trophic level 1 energy}}$ x 100 ; **CREDIT** sample figures. e.g. if producer energy 20 000 kJ m^{-2} and herbivore 2000 kJ m^{-2} calculation is 2000 / 20000 × 100 = 10% **CREDIT** $\frac{\text{Energy available after transfer}}{\text{Energy available before transfer}}$ x100
			Plus any 3 of the following:		**IGNORE** ref to productivity
			2(a sample of) producers collected;		**CREDIT named examples for 2 and 3**
			3(a sample of) herbivores /primary consumers collected;		**ACCEPT** 'organisms at each trophic level collected' for **1 mark**
			4(collected from) the same area;		
			5(measure) biomass / dry mass (of individual or population);		**5 ACCEPT** wet / fresh, mass **5 IGNORE** mass unqualified / pyramids of biomass
			6energy content calculated of producer **and** herbivore;		**6 ACCEPT** expressed as J / KJ / MJ, per gram **IGNORE** calories per gram
			7use of calorimeter / described;		**7** e.g. burn sample, in oxygen / in measure temperature increase **ACCEPT** use of published tables for energy values of, fresh /wet, mass
					Examiner's Comments Few candidates scored 4 marks on this question. Where candidates gained 2 or 3 marks, this was for the use of dry or biomass and the need to measure the energy content of both the producers and herbivores. Many candidates were able to

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>identify the use of a bomb calorimeter with detailed descriptions of their use. However, most candidates failed to correctly give the calculation needed to work out the percentage efficiency of energy transfer, and so failed to gain full marks. Weaker candidates talked about pyramids of biomass, and measuring dry mass by the use of calorimetry. Some candidates missed the point of the question altogether, and gave a theoretical account of energy flow between trophic levels.</td></tr>
<tr><td></td><td>b</td><td></td><td><table><tr><th>Goal</th><th>Letter</th></tr><tr><td>improving soil that is low in nutrients for the growing of wheat</td><td>F ;</td></tr><tr><td>preventing the spoilage of fruits after picking</td><td>E ;</td></tr><tr><td>reducing the impact of a fungal disease on yields from cucumber plants</td><td>A / B ;</td></tr><tr><td>producing strawberry plants that grow quicker and fruit earlier</td><td>A / B ;</td></tr><tr><td>making sugar syrup from waste starch</td><td>D ;</td></tr><tr><td>producing large amounts of a fungus for food</td><td>C ;</td></tr></table></td><td>6</td><td>Mark the first answer in each box. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks

ACCEPT A / B

ACCEPT C

Examiner's Comments

A Generally well answered question, with the majority of candidates gaining full marks. Producing strawberry plants which grow quicker was the most common point to get wrong, with the choice of E given. Some candidates put multiple letters in the boxes, which examiners allowed, if all letters given were present as options in the mark scheme.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
8	a		**1** pioneers arrive, ***before*** climax / ***earlier***; **ora** **2** pioneer communities subject to, ***greater*** / ***more***, change / succession / replacement; **ora** **3** pioneer community (usually) has, ***less / lower***, biodiversity; **ora** **4** *idea that* pioneer community is (often) ***less***, stable / self-sustaining; **ora** **5** pioneer community has ***lower*** biomass; **ora** **6** AVP;	2 max	**Note: All mark points are comparative** **1 CREDIT** pioneers arrive first / climax arrive last **6** e.g. species in pioneer community better adapted to (named) abiotic factor(s) **and** those in climax community better adapted to (named) biotic factor(s) **Examiner's Comments** Almost all candidates got one mark on this question - usually that the pioneer species was first to arrive, and the climax community last. Occasionally a candidate would gain a mark for a comparative statement about biodiversity, but the issue with gaining that second marking point was the lack of comparison (e.g. lower / greater biomass, more stable / less stable) which only the most capable candidates achieved.

Question			Answer/Indicative content	Marks	Guidance
	b		**1** decomposition is break down, dead matter / waste **or** decomposition is conversion of organic matter to inorganic; **2** denitrification is conversion of nitrates to nitrogen (gas); **3** decomposition increases, mineral / nitrate, supply **and** denitrification reduces, mineral / nitrate, supply;	2 max	**1 IGNORE** putrefication **1 CREDIT** for **inorganic**: carbon dioxide / CO_2 / water / H_2O / ammonium compounds / ammonium ions / NH_4^+ **IGNORE** ammonia / NH_3 **2 CREDIT** correct formulae (NO_3^- and N_2) **DO NOT CREDIT** nitrogen oxides **3 CREDIT** decomposition returns, mineral / nitrate, to soil **and** denitrification removes mineral / nitrate, to soil **Examiner's Comments** The majority of candidates got a mark for their description of decomposition. Most candidates knew what denitrification was, but talked about ammonia being converted into nitrogen as opposed to nitrates, or confused denitrification with nitrification.

Question			Answer/Indicative content	Marks	Guidance
	c		**1** nitrogen fixation is the conversion of (atmospheric) nitrogen into, ammonia / ammonium compounds / ammonium ions; **2** nitrification is the conversion of, ammonia / ammonium compounds / ammonium ions, into nitrite / nitrate; **3** correct ref to microorganisms involvement in both processes;	2 max	**1 CREDIT** N_2 / NH_3 / NH_4^+ **2 CREDIT** NH_3 / NH_4^+ **CREDIT** NO_2^- / NO_3^- **DO NOT CREDIT** nitrate to nitrite **3** e.g. nitrogen fixation involves, *Rhizobium* / *Azotobacter* / *Nostoc* **and** nitrification involves, *Nitrosomonas* / *Nitrobacter* **Examiner's Comments** This question showed some confusion amongst many candidates in terms of these two processes. It was not uncommon to see nitrogen being converted into ammonia and nitrates in nitrogen fixation, and for ammonia to be converted into nitrates and then nitrites for nitrification. However, those candidates who had a clear understanding of these processes scored both marks easily and often named the micro organisms involved correctly.
			Total	**6**	
9			C ☐	1	
			Total	**1**	
10			C ☐	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
11	a	i	lay tape measure out from edge of pond □ place quadrat beside tape measure □ identify species of buttercup in quadrat □ count number of plants of each species (in quadrat) □ repeat for positions of quadrat along tape □	Max 3	**ACCEPT** measure % cover of each species **ACCEPT** count squares containing plants of each species
		ii	three columns with clear headings □ quadrat number / distance from pond in left hand column □ number of plants / % cover in right hand column(s) □	Max 2	**ACCEPT** two columns where second column is divided into two forseparate species
	b		predation / herbivory □ competition □ correct ref to organisms living in soil □	Max 1	
			Total	**6**	