Biology Paper 2 Electives BY TOPIC AL CE DSE 1980-2022	TOPIC
Applied Ecology	**Human impacts on the environment**
	Pollution control and conservation

SECTION B Applied Ecology

Answer **ALL** parts of the question.

2(a) The major purpose of deforestation in the tropical rainforest is to turn it into a grassland for cattle farming.

(i) The table below shows the comparison of plant communities within a primary rainforest and a grassland formed after deforestation:

Type of plant community	Average plant height (m)	Number of plant species	* Percent coverage (%) of individual plant species	
Primary rainforest	28	18	Species A	15
			Species B	19
			Species C	12
			Species D	20
			Species E	14
Grassland	0.3	3	Species H	95

* Only species with at least 10% of coverage are included.

(1) What would be the effect of converting a tropical rainforest to a grassland on the average plant height and number of plant species? (1 mark)

(2) For estimating the relative abundance of plant species in the above case, why was percent coverage a better measurement than the number of individual species? (1 mark)

(3) With reference to the percent coverage of individual plant species, what was the effect of deforestation on the composition of the plant community? (3 marks)

(ii) Soil porosity (space between soil particles) was determined for soil samples collected from the rainforest and grassland. The soil samples were then incubated in the laboratory for 7 days. After that, the net changes in the amounts of ammonium content and inorganic nitrogen (i.e. nitrate and nitrite) were calculated. The results are shown in the table below:

Soil sample	Soil porosity (%)	Amount of ammonium (mg kg^{-1} soil)	Amount of inorganic nitrogen (mg kg^{-1} soil)
Primary rainforest	80	13	14
Grassland	60	7.3	9.8

(1) Based on the information in the table, deduce the effect of deforestation on the oxygen level of the soil. (2 marks)

(2) With reference to the nitrogen cycle and the answer in (1), answer the following questions:

(I) Explain the difference in the amount of ammonium between the samples taken from the primary rainforest and the grassland. (2 marks)

(II) Explain the difference in the amount of inorganic nitrogen between the samples taken from the primary rainforest and the grassland. (2 marks)

2(b) During World War II, much of the forests in Hong Kong had been cleared for firewood. After the war, the Government began to build new reservoirs and restore the existing ones. At that time, imported tree species were planted in areas around these reservoirs.

(i) Explain why planting trees in the area nearby is important to the functioning of reservoirs. (2 marks)

(ii) Tai Po Kau Nature Reserve comprises a secondary forest with native tree species and an afforestation area with imported tree species. A survey about the bird community was conducted in these two areas. The results are shown in the table below:

	Secondary forest with native tree species	Afforestation area with imported tree species
Total number of bird species	44	46
Number of forest-dependent bird species	16	9
Number of migrating bird species	28	37
Number of species nested in the forest	12	2
Number of individual birds per hectare	44	12

(1) What is meant by a secondary forest? (1 mark)

(2) In what ways are forests important to bird communities? State ***two*** of them. (1 mark)

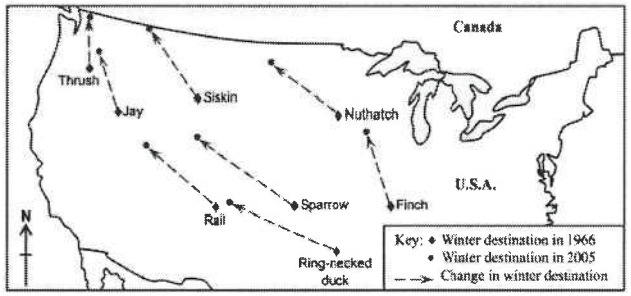
(3) Suggest ***one*** way by which birds are beneficial to tree communities. (1 mark)

(4) Based on the above results, deduce which type of tree, native tree species or imported tree species, has a greater contribution to the local bird community. (4 marks)

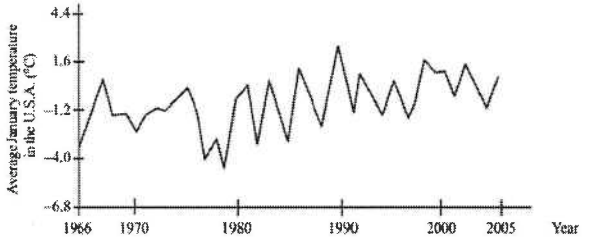
Applied Ecology

Human impacts on the environment
2012pp(2a)

2. (a) Many bird species living in Canada migrate southwards to the U.S.A. to spend the winter. The diagram below shows the destinations of some of these bird species in the U.S.A. in the winters of 1966 and 2005:



The average January temperatures in the U.S.A. from 1966 to 2005 are shown in the following graph:



(i) Suggest one way which can be used to track the migration route of birds. (1 mark)

(ii) (1) State the general trend shown in the average January temperature in the U.S.A. from 1966 to 2005. (1 mark)

(2) Relate the change in the winter destination of bird species in the U.S.A. with the change in average January temperature in the U.S.A. from 1996 to 2005. Suggest, from an ecological point of view, a reason for the change in the winter destination. (2 marks)

(3) Suggest **two** possible effects caused by the change in the winter destination of these migratory bird species on native bird species. (2 marks)

(4) It is believed that the trend in the average January temperature in the U.S.A. is due to human activities. Explain how human activities may have caused this trend. (4 marks)

2012sp(2a)

2.(a) The table below shows the total fish catch and the total number of days spent on catching tuna for all the fishing boats, i.e. the fishing effort, in the Atlantic Ocean from 1980 to 1987:

Year	Total fish catch (ton x 10^3)	Fishing effort (number of days x 10^3)	Fish catch per unit fishing effort (ton per day)
1980	40	5	8.00
1981	45	8	5.63
1982	44	12	3.67
1983	60	20	3.00
1984	80	30	2.67
1985	85	35	2.43
1986	90	40	*x*
1987	100	60	*y*

(i) Calculate the values of *x* and *y*, which represent the fish catch per unit fishing effort in the years of 1986 and 1987 respectively. (1 mark)

(ii) Plot a graph to show the fish catch per unit fishing effort from 1980 to 1987. (3 marks)

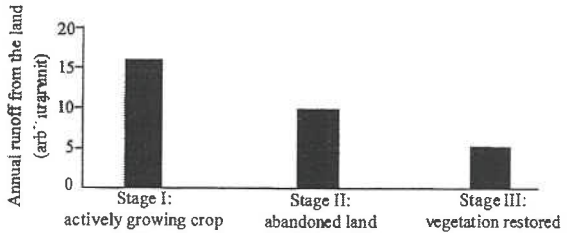
(iii) Referring to your graph and the data given above, explain the change in fish catch per unit fishing effort from 1980 to 1987. (3 marks)

(iv) Suggest ***two*** control measures for fishing and describe how each of them can help to maintain a sustainable supply of fish. (4 marks)

2012(2a)

2.(a) In shifting agriculture, plots of land on hill slopes are cleared of trees so as to grow crops. The trees are then burnt and the ash is dispersed throughout the field as fertilizer. After growing crops for several years until the soil loses its fertility, the land will be abandoned. After a period of time, the land will be recolonized by natural vegetation. Figure 2A below shows the annual runoff (water run off from soil) at 3 different stages of shifting agriculture:

Figure 2A



(i) Briefly describe the process in Stage II that leads to the restoration of the natural vegetation in Stage III. (3 marks)

(ii) Suggest *two* agricultural activities which could account for the difference in the annual runoff between Stage I and Stage III. (5 marks)

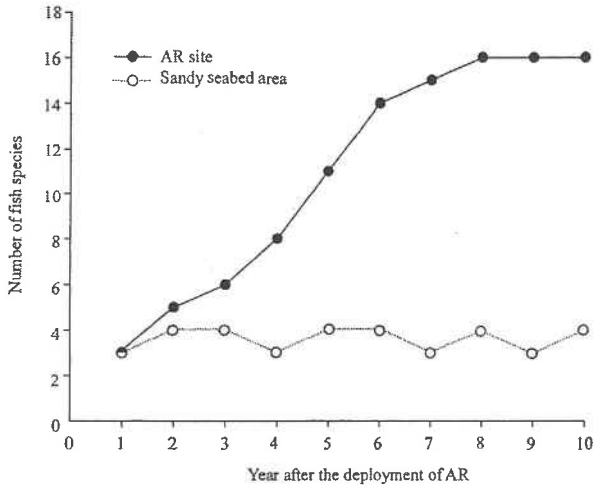
(iii) As soil nutrients are depleted in Stage I, the leaves of the crops become yellow. Which soil nutrient is probably lacking? Explain your answer. (2 marks)

(iv) State *two* ways in which soil nutrients are lost from land. (2 marks)

2012(2b)

2.(b) An artificial reef (AR) is a man-made structure deployed on the seabed to enhance biodiversity. A ten-year study was carried out on a sandy seabed to investigate the effect of an AR on the number of fish species. The number of fish species at the AR site (around and within AR) was compared with another similar sandy seabed area nearby. The results are shown in Figure 2B below:

Figure 2B



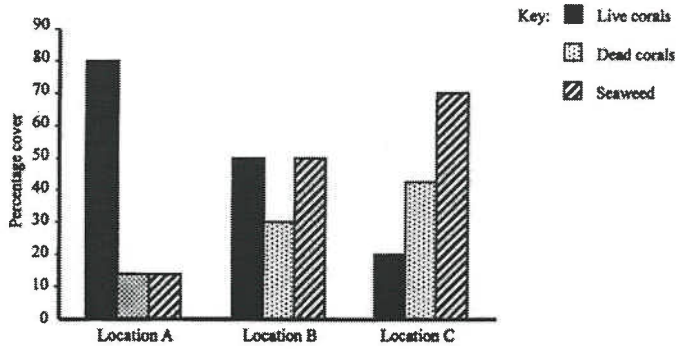
(i) Compare the results obtained in terms of the number of fish species at the AR site and the sandy seabed area. (3 marks)

(ii) Explain why AR has an effect on the number of fish species at the AR site. (3 marks)

(iii) Give *two* criteria for the selection of suitable materials for AR construction and explain the importance of these criteria. (2 marks)

2014(2b)

2(b) A field survey was conducted to determine the health status of the coral communities at three locations A, B and C on the sea bottom along a coastline. At each location, the percentage cover of live corals, dead corals and seaweed was determined. The results are shown in the graph below:



(i) At which location did the coral communities appear to be the healthiest? Support your answer with data. (2 marks)

(ii) (1) Suggest *one* human activity which may have led to the highest percentage cover of seaweed in location C. Explain your answer. (3 marks)

(2) Suggest *one* possible consequence of this human activity that may have resulted in the low percentage cover of live corals at location C. (1 mark)

(iii) (1) Hoi Ha Wan was chosen to be a marine park for the richness of its coral community. Explain the ecological importance of coral communities. (3 marks)

(2) Suggest *one* human activity that should be prohibited in a marine park. (1 mark)

2016(2b)

2(b) Arsenic is poisonous to humans. Contamination of soil with arsenic can occur as a result of using arsenical pesticides and herbicides, mining activity and waste disposal. An experiment was conducted to study the effect of phosphate addition on the growth of wheat and the accumulation of arsenic in different parts of the wheat. 100 pots with uncontaminated soil and 100 pots with arsenic-contaminated soil were prepared for growing wheat. Phosphate was added to 50 pots from each group. The dry masses of grain and plant body (shoot and root), and the distribution of arsenic in different parts of the wheat after seven months are shown in the table below:

	Dry mass of wheat (g pot $^{-1}$)		Distribution of arsenic in the wheat
	Uncontaminated soil	Arsenic-contaminated soil	grown in arsenic-contaminated soil (%)
No phosphate added			
• grain	8	2	10
• plant body	14	5	90
Phosphate added			
• grain	20	12	2
• plant body	15	14	98

(i) Compare the effects of arsenic on the growth of grain and plant body when no phosphate was added. (2 marks)

(ii) With regard to the growth of wheat in the two types of soils, what can you conclude about the effect of phosphate addition on the growth of grain and plant body? (4 marks)
(Note: You should refer to the growth of wheat in uncontaminated soil as the control.)

(iii) Comment on the effect of phosphate addition on the distribution of arsenic in different parts of the wheat. (2 marks)

(iv) With reference to the above results, what is the significance of phosphate addition to the agricultural production of wheat in arsenic-contaminated land? (2 marks)

2(a) A marine protected area is established in open sea where fishing is prohibited to ensure the fishery resources are sustainable. Outside the protected area, bottom trawling is allowed. A preliminary study was conducted to estimate the animal biomass (kg km^{-2}) at six randomly chosen sites as shown in Diagram I. The animal biomass of each site is shown in Diagram II.

Diagram I

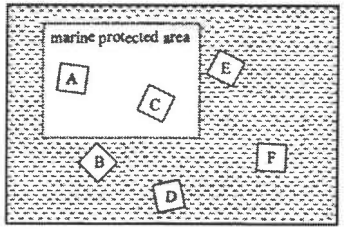
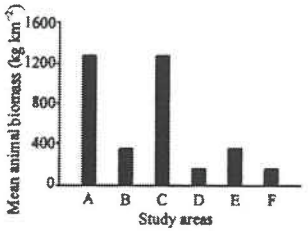


Diagram II



(i) Bottom trawling is a fishing method in which fish nets are laid on the sea bottom and towed by fishing boats. Suggest *two* potential effects caused by bottom trawling on the physical environment on the sea bottom. (2 marks)

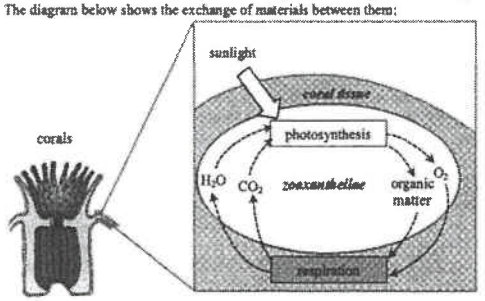
(ii) (1) Comparing the biomass of the sites within and outside the protected area, what pattern do you observe? (2 marks)

(2) Suggest a possible explanation for this pattern. (3 marks)

(iii) What is the limitation of this preliminary study? What measurement should be taken to increase the validity of the study? (4 marks)

(iv) State *one* marine protected area in Hong Kong. (1 mark)

2(b) Corals appear colourful because they have mutualistic unicellular algae called zooxanthellae in their bodies. The diagram below shows the exchange of materials between them:



(i) When the seawater temperature increases, corals will expel zooxanthella. This is known as coral bleaching. After bleaching, the corals may eventually die due to a deterioration in their health. Based on the information from the diagram, suggest why the health of coral deteriorates. (1 mark)

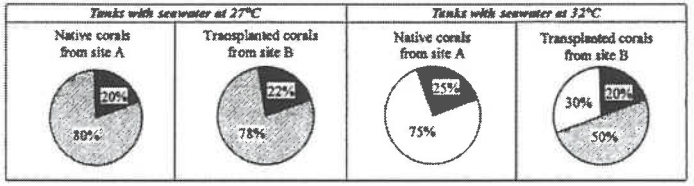
(ii) Increased atmospheric carbon dioxide level is believed to be the cause of increased seawater temperature. Explain why. (3 marks)

(iii) A transplantation experiment was conducted to study the effect of increased seawater temperature on the health of the corals, as follows:

Site A Temperature range: 27°C - 30°C	→ Corals from site A were transplanted to site B →	Site B Temperature range: 27°C - 35°C

After 14 months, native corals from Site A and transplanted coral from Site B were collected and put into tanks of seawater with different temperature settings. The charts below show the health of the corals after 6 months:

Key: ▨ Healthy ☐ Bleached ■ Dead



(1) Compare the effect of increased seawater temperature on the health of the native corals and transplanted corals. Support your answer with information from the above charts. (3 marks)

(2) Under the threat of global warming, what is the implication of this study for coral bleaching? (1 mark)

2019(2b)(more about biodiversity in compulsory part)

2(b) Mining activities often produce large quantities of heavy metal wastes, which cause contamination of the ecosystem. The photographs below show an abandoned mining site and the ecological restoration of this mining site after 10 years:

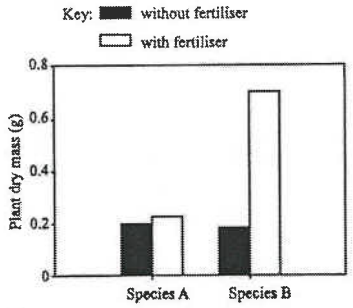
Photograph I – Abandoned mining site

Photograph II – the mining site after ecological restoration

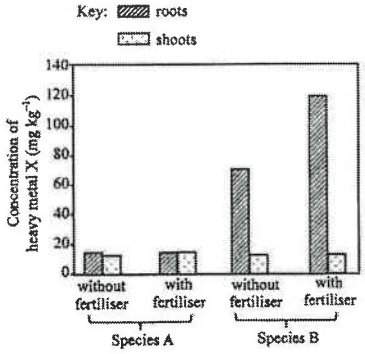
(i) Besides heavy metal pollution, state *two* other ecological problems of the abandoned mining site. (2 marks)

(ii) In a study, two native plant species, A and B, were tested for their suitability to restore an abandoned mining site. Their seedlings were planted in pots containing soil from the mining site with a high concentration of heavy metal X. Half of the pots of each plant species were supplied with fertiliser but not the other half. Graph 1 shows the dry masses of plants in the eighth week of the experiment and Graph 2 shows the concentrations of heavy metal X in the roots and shoots:

Graph 1



Graph 2

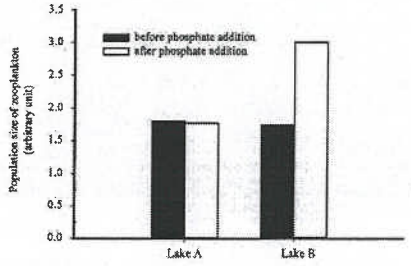


DSE21_02(b)

2(b) Algal bloom commonly occurs when an aquatic ecosystem is polluted by domestic sewage. Lakes A and B have similar environmental conditions while the frequency of occurrence of algal bloom in Lake B is lower than that in Lake A. The major food chains of the two lakes are shown below:

Lake A: phytoplankton → zooplankton → Fish Species 1
Lake B: phytoplankton → zooplankton → Fish Species 1 → Fish Species 2

It is hypothesized that the number of trophic levels of the food chain affects the frequency of occurrence of algal blooms in the two lakes. To test this hypothesis, phosphate was added to the lakes and the population sizes of the zooplankton were monitored. The bar chart below shows the population sizes of zooplankton in Lakes A and B before and after the addition of phosphate:



(i) What would be the effect of phosphate addition on the population size of phytoplankton? Explain your answer. (2 marks)

(ii) With reference to the bar chart, suggest why the frequency of occurrence of algal bloom in Lake B is lower than that in Lake A. (3 marks)

(iii) Based on the food chain of Lake B, explain why there is a higher zooplankton biomass in Lake B after phosphate addition. (3 marks)

(iv) Explain why algal bloom leads to the reduction of dissolved oxygen in water at night. (2 marks)

Pollution control and conservation
2012pp(2b)

2. (b) Forests provide humans with valuable resources. Proper forest management is needed when exploring new uses of forests to ensure sustainable forestry.

(i) The combustion of fossil fuel releases acidic gases which may cause acid rain. State and explain **two** environmental impacts of acid rain. (4 marks)

(ii) Some scientists are exploring the use of forest woody biomass to replace the fossil fuel used in power plants. Trees are logged from two forests, A and B, for this research and other uses. The table below shows the distribution of the inorganic nutrients nitrogen and magnesium in these two forests:

	Forest A		Forest B	
	Nitrogen (%)	Magnesium (%)	Nitrogen (%)	Magnesium (%)
Biomass above forest floor	35	70	5	25
Biomass on forest floor	5	5	5	5
Biomass below forest floor	60	25	90	70
Total	100	100	100	100

Based on the difference in the distribution of inorganic nutrients of the two forests, explain which forest will reestablish itself more quickly after logging. (3 marks)

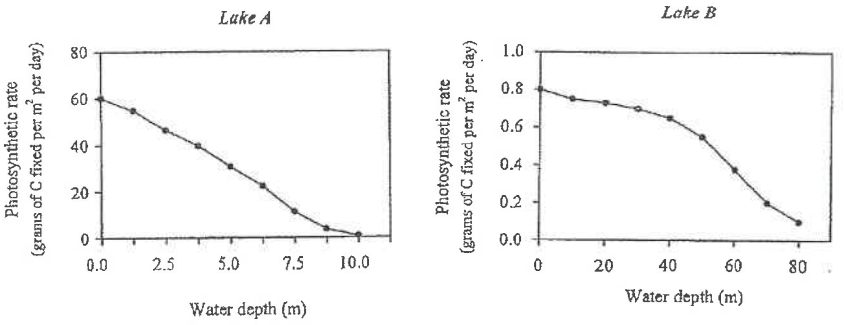
(iii) Over-exploitation of forest resources leads to a decrease in biodiversity.

(1) Provide **one** reason why biodiversity is important. (1 mark)

(2) Reforestation is a way to restore a forest. In earlier years, reforestation depended mainly on exotic tree species imported from other countries and most of the plantations were formed by a single exotic tree species. State **one criterion** when choosing an appropriate exotic tree species for reforestation. Give **one disadvantage** of forming a plantation using a single tree species. (2 marks)

2012sp(2b)

2.(b) The diagrams below show the changes in photosynthetic rate with water depth of two lakes, A and B. One of the lakes is polluted by chemical fertilizers leached from nearby farmlands.



(i) Explain the change in photosynthetic rate with increasing water depth in lake A. (2 marks)

(ii) Which of these lakes is polluted by chemical fertilizers? Explain your answer. (3 marks)

(iii) Which lake is more likely to experience a greater diurnal fluctuation (i.e. between day and night) of dissolved oxygen content? Explain your answer. (4 marks)

2013(2a)

2(a) An experiment was conducted to study the effect of acid rain on the growth of bean seedlings planted in pots containing two different soils, either with or without heavy metal X. The same amount of water with a pH of either 6 or 3 was used to water the seedlings every day and their average increase in fresh weight was measured after 30 days. The results are shown in the table below:

	Average increase in fresh weight of bean seedling (g)	
	pH 6	pH 3
Soil without heavy metal X	13.0	7.7
Soil with heavy metal X	7.5	4.3

Note: Rainwater normally has a pH value of 6.

(i) What conclusion can you draw from the results of the experiment? (3 marks)

(ii) During the experiment, excess water that came out of the potted plants was collected and the amount of heavy metal ion X in it was determined. The table below shows the results:

	pH 6	pH 3
Amount of heavy metal ion X in excess water (arbitrary unit)	5	10

Based on this information, explain the effect of adding water of pH 3 to the seedlings in soil containing heavy metal X. (3 marks)

(iii) State the air pollutants that cause acid rain and state the human health problem associated with these air pollutants. (3 marks)

2013(2b)

2(b) Pollutant Y was found in sewage discharge from industry, leading to bioaccumulation in organisms.

(i) Give *three* properties of chemicals that make them liable to bioaccumulation. (3 marks)

(ii) Specimens were collected from a site where pollutant Y was known to be discharged. The levels of pollutant Y in sea water, sediment and some organisms collected from the site are listed in the following table:

	Concentration of pollutant Y (arbitrary unit)
Seawater	2
Sediment	36
Clams	163
Birds	1557
Fish	519

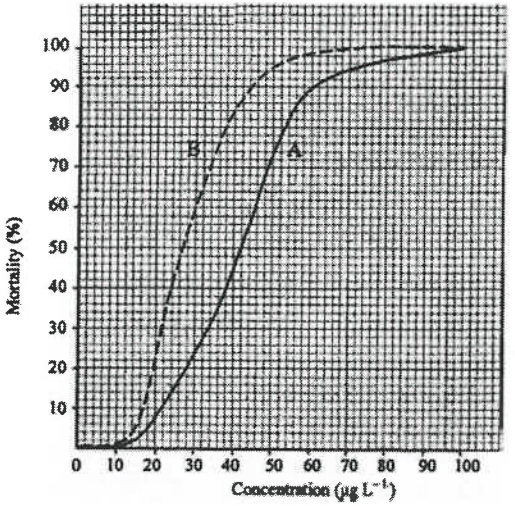
Based on the information in the above table, which organism is most likely the top consumer of the food chain in the site? Explain your answer. (3 marks)

(iii) With reference to the functional role of organisms in an ecosystem, give *one* group of organisms not included in the above table. State the ecological significance of this group of organisms. (3 marks)

(iv) If humans consumed fish contaminated with pollutant Y, which human organ would have a high concentration of this pollutant? Explain your answer. (2 marks)

2014(2a)

2(a) The graph below shows the mortality of a species of freshwater shrimp after it has been exposed to various concentrations of two fat-soluble pesticides, A and B, for 24 hours:



(i) (1) Determine the concentrations of pesticides A and B at which 50% of the shrimps were killed. (1 mark)

(2) Deduce which pesticide, A or B, was more toxic. (2 marks)

(ii) To further study the toxicity of pesticides A and B, the shrimps were exposed to either pesticide A or B at a concentration of 5 μg L^{-1} for 4 days. At the end of the study, the concentrations of pesticides in the body tissue of the shrimps were determined.

(1) 50 μg kg^{-1} of pesticide A and 80 μg kg^{-1} of pesticide B were found in the body tissue of the shrimps. Suggest *three* possible reasons why there was a higher concentration of pesticide B than pesticide A in the body tissue. (3 marks)

(2) Why was a concentration of 5 μg L^{-1} adopted for the pesticides used in the experiment? (1 mark)

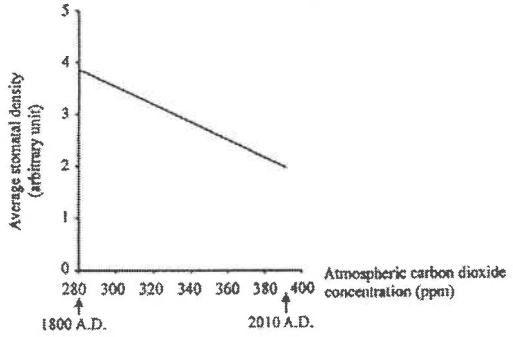
(iii) A field survey was conducted to investigate the concentration of pesticide A in the body tissue of herbivorous fish and carnivorous fish. What difference in the concentrations of pesticide A would you expect to find between these two types of fish? Explain your answer. (3 marks)

2(a) The atmospheric concentration of carbon dioxide has been increasing in the last 210 years. The increase is believed to be the major cause of global climate change.

(i) Explain why the increase in carbon dioxide concentration leads to a change in the atmospheric temperature. (2 marks)

(ii) It has been suggested that the rate of increase in carbon dioxide concentration can be slowed down by photosynthesis. What is the biological principle behind this suggestion? (3 marks)

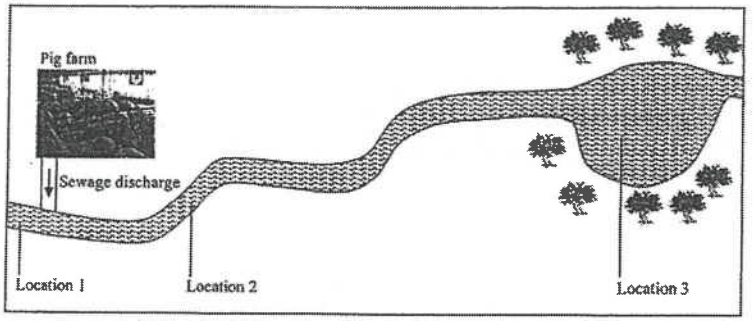
(iii) The graph below shows the changes in the average stomatal density of some plant species and the atmospheric carbon dioxide concentration over the past 210 years:



(1) How may the observation contradict the suggestion given in (ii)? (3 marks)

(2) It has been hypothesized that the decrease in the average stomatal density of plant species may further affect the regional climate. With reference to the water cycle, explain the rationale behind this hypothesis. (2 marks)

2(b) A pig farm is located in the upper course of a freshwater stream. Sewage is discharged illegally into the stream. To investigate the impact of the sewage discharge, water samples and aquatic animals were collected from upstream near to the sewage discharge (Location 1) and 50 m downstream (Location 2). The diagram below shows the position of the pig farm and the stream:



The table below shows the data obtained at locations 1 and 2:

	Location 1	Location 2
Dissolved oxygen (% saturation)	95	22
Animal community	Fish species A	Fish species C
	Fish species B	Larvae of insect species A
	Snail species A	
	Crab species A	

(i) (1) Explain the change in the level of dissolved oxygen as water flows from Location 1 to Location 2. (4 marks)

(2) With reference to the change in the level of dissolved oxygen, explain the differences in the animal species at Location 2 as compared to Location 1. (2 marks)

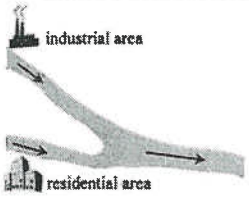
(ii) It was found that the level of dissolved oxygen 1 km downstream (Location 3) from the sewage discharge had been restored to 95%.

(1) Suggest how the level of dissolved oxygen was restored at Location 3. (2 marks)

(2) Although the level of dissolved oxygen had recovered, the animal community found at Location 3 was different from that at Location 1. Suggest why. (2 marks)

2016(2a)

2(a) Water samples A and B are collected from an industrial area and residential area along a river respectively. Their locations are shown in the map and the analysis of water samples is shown in the table below:



	Water sample A (industrial area)	Water sample B (residential area)
Biochemical oxygen demand, (BOD, 5 days 20°C) (mg L^{-1})	20	100
Heavy metal (ppm)	30	0.01
Antibiotic residues (μg L^{-1})	0.1	50

(i) Give the particular type of pollutant in water sample B that can contribute to the difference in BOD between water samples A and B. Explain your answer. (4 marks)

(ii) Some people like to go fishing in the river next to the industrial area and consume the fish. Explain the health risks of consuming the fish. (4 marks)

(iii) (1) Suggest why antibiotic residues are present in water sample B. (1 mark)

(2) Suggest *one* possible effect of antibiotic residues on the ecosystem. (1 mark)

2018(2a)

2(a) (i) The concentrations of copper and cadmium per unit biomass in marine phytoplankton and its consumer, filter-feeding bivalves, were determined in a study. Their concentrations are shown in the table below:

	Copper (arbitrary unit)	*Cadmium (arbitrary unit)*
Concentration in phytoplankton (C_P)	20	0.6
Concentration in bivalve (C_B)	16	1.2
C_B/C_P Ratio	0.8	?

(1) Calculate the C_B/C_P ratio for cadmium. (1 mark)

(2) What is the implication of a C_B/C_P ratio greater than 1? (1 mark)

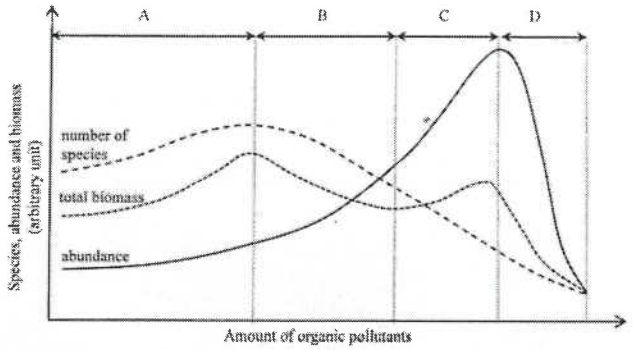
(3) Compare the C_B/C_P ratios for copper and cadmium. List *two* possible reasons for the difference. (3 marks)

(ii) Briefly describe an experiment to study the effect of different concentrations of cadmium on the mortality of bivalves. (3 marks)

(iii) Cadmium in rechargeable batteries is one of the sources of cadmium pollution in the environment. Suggest *two* possible ways to reduce such pollution. (2 marks)

2018(2b)

2(b) Invertebrates that live on, in and near the seabed are important components of the coastal ecosystem. These invertebrates feed on organic matter. The diagram below shows the effects of increasing amounts of organic pollutants from household sewage on the invertebrate community in a harbour in terms of the number of species, abundance (total number of organisms) and total biomass:



(i) Explain why the invertebrate community expands when the amount of organic pollutants increases at Stage A. (2 marks)

(ii) It is found that the proportion of larger invertebrates in the community declines in Stage B as the amount of organic pollutants continues to increase.

(1) With reference to the graph, give evidence to support the above statement. (3 marks)

(2) Suggest why the increase in the amount of organic pollutants will lead to a decline in the proportion of larger invertebrates in the community at Stage B. (3 marks)

(iii) Although the abundance and biomass of invertebrates continues to increase at Stage C, the community is deteriorating. State a piece of evidence from the graph to support this statement. (1 mark)

(iv) Suggest *one* property of the dominant species in the invertebrate community at Stage C. (1 mark)

2019(2a)

2(a) An artificial wetland was introduced to treat sewage in some small villages in Africa and the effluent collected was used for irrigating farms. This helped to alleviate the problems of water shortage and sewage treatment. In a study, domestic sewage after primary treatment was conveyed to either a sewage treatment plant or an artificial wetland, and the effluents were collected and compared.

(i) Briefly describe the processes involved in the primary treatment of sewage. (2 marks)

(ii) The table below shows some parameters in the influent and effluents collected from the sewage treatment plant and the artificial wetland:

	Influent (sewage after primary treatment)	Effluent from different systems	
		Sewage treatment plant	Artificial wetland
Oxygen content ($mg\ L^{-1}$)	5.0	5.3	3.5
Organic nitrogen content ($mg\ L^{-1}$)	35	3	12
Phosphate content ($mg\ L^{-1}$)	29	28	27
Magnesium content ($mg\ L^{-1}$)	42	40	41

(1) With regard to the handling of organic nitrogen in the two systems, explain the difference in the organic nitrogen content in the effluents from the sewage treatment plant and the artificial wetland. (4 marks)

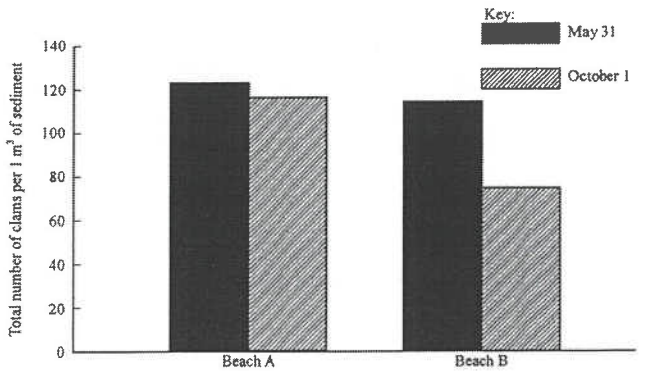
(2) Using the effluent of this study to irrigate the farms is advantageous to the growth of crops. Apart from the presence of nitrates, briefly explain another advantage in terms of the synthesis of biomolecules. (2 marks)

(iii) State *two* advantages of adopting an artificial wetland over a sewage treatment plant for small villages. (2 marks)

2020(2a)

2(a) A study was conducted on beaches A and B to investigate the effect of clam harvesting on the animal community on sandy shores. On beach A, clam harvesting was forbidden all year round. On beach B, clam harvesting was allowed from June to September. Field sampling was conducted on both beaches on May 31 and October 1. Animals in the sediment were identified and counted.

(i) The diagram below shows the number of clams collected from the two beaches on May 31 and October 1:



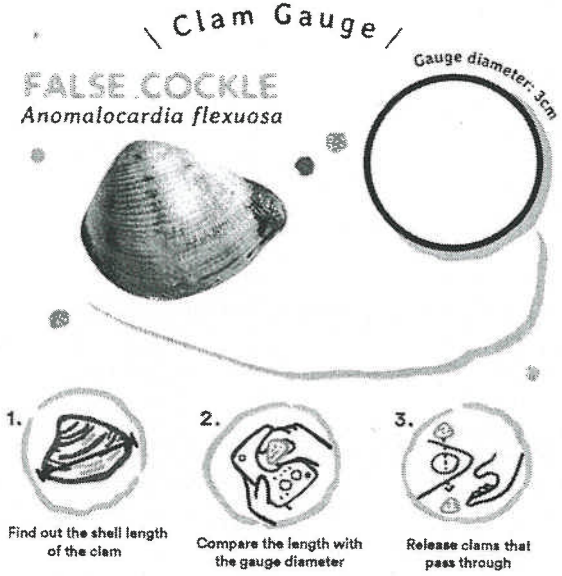
Describe the change in the density of clams on the two beaches. (2 marks)

(ii) The table below shows the animal species composition of beaches A and B on May 31 and October 1 (the data on clams are excluded):

		May 31		October 1	
	Animal species	No. of individuals per 1 m^3 of sediment	Percentage of total individuals	No. of individuals per 1 m^3 of sediment	Percentage of total individuals
Beach A	Species 1	20	31.3	19	30.2
	Species 2	15	23.4	16	25.4
	Species 3	8	12.5	8	12.7
	Species 4	21	32.8	20	30.7
Beach B	Species 1	19	30.6	7	20.6
	Species 2	16	25.8	5	14.7
	Species 3	7	11.3	21	61.8
	Species 4	20	32.3	1	2.9

Based on the results in (a) (i) and (a) (ii), deduce the effect of clam harvesting on the species diversity of the animal community on sandy shores. (4 marks)

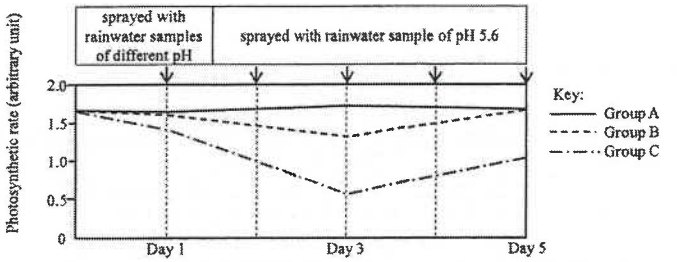
(iii) The World Wildlife Fund in Hong Kong has developed a Clam Gauge as a guideline for harvesting clams. The gauge for a particular calm is shown below:



Explain how we can help conserve the clam community by harvesting only clams which cannot pass through the gauge. (3 marks)

2(b) Normal rainwater has a pH of around 5.6. Acid rain was first noted in the 17th century. At that time, rainwater with pH readings below 2.5 were recorded in industrial areas.

(i) In 1986, an experiment was conducted to study the effect of acidity of rainwater on the photosynthetic rate of a lichen species. The lichens were divided into three groups: Group A served as the control, which was sprayed with rainwater sample of pH 5.6 every day; Groups B and C were sprayed with rainwater samples of pH 3.5 and 2.5 respectively on Day 1 and then sprayed with rainwater sample of pH 5.6 on Day 2 until Day 5.



(1) Compare the effects of spraying rainwater samples of different pH on the photosynthetic rate of the lichen. (4 marks)

(2) The chart below shows the weather in city Y in a month during the rainy season. Based on the results of the experiment, explain why the lichen is rarely found in the industrial area of city Y. (3 marks)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

(ii) State *two* major air pollutants and describe how they cause the formation of acid rain. (2 marks)

(iii) State *two* effects of acid rain on soil minerals. (2 marks)

DSE21_02(a)

2(a) Conventional farming engages the use of artificial chemicals such as herbicides and insecticides while organic farming does not. A survey comparing a conventional farm and an organic farm was conducted. The survey involved random sampling in areas within the farm and the areas around the farm at different times of a year. The data are shown in the table below:

		Conventional farm		Organic farm	
		Around the farm	Within the farm	Around the farm	Within the farm
Species richness (number of species)	Plants other than crops	7	3	28	18
	Pollinators	1	0	10	6
Abundance (number of individuals)	Pest A	310	160	51	49
	Predators of A	9	3	24	11

(Note: The numbers shown are the mean values rounded up to the nearest integer.)

(i) With reference to the data collected within the farms, discuss the effectiveness of the use of herbicides. How can the use of herbicides bring about an increase in the yield of crop production? (3 marks)

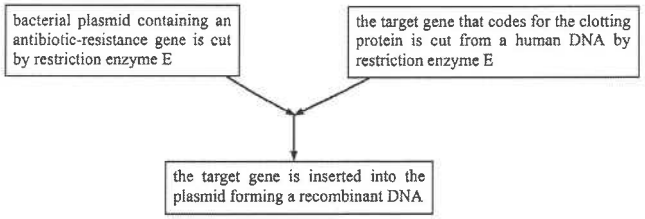
(ii) According to the data collected within the farms, discuss the effectiveness of chemical control and biological control on the population of pests. Explain your answer with supporting evidence from the data. (4 marks)

(iii) With reference to species richness, explain why organic farming is beneficial to the sustainable development of communities in the areas around the farm. (3 marks)

Biotechnology

Technology in Modern biotechnology
2012sp(4)

4.(a) In some people, a gene mutation results in a failure to produce a blood clotting protein and this leads to the disease haemophilia. One way to treat this disease is by introducing an external source of the clotting protein into these people's blood. The clotting protein can be produced by recombinant DNA technology. The flow chart below outlines the major steps of producing the recombinant DNA:



(i) (1) What is a bacterial plasmid? (1 mark)

(2) Give ***two*** reasons why plasmids are commonly used as vectors in recombinant DNA technology. (2 marks)

(ii) In most cases, the restriction enzyme used to cut the target gene from the human DNA should be the same as that used for cutting the plasmid. Explain the importance of this in the formation of the recombinant DNA. (2 marks)

(iii) Outline how the clotting protein is produced on a large scale after obtaining the recombinant DNA. (4 marks)

(iv) Traditionally, the clotting protein is obtained by extraction from donated blood. Give ***two*** advantages of using the clotting proteins produced by recombinant DNA technology over that obtained from the traditional source. (2 marks)

4. (b) Polymerase chain reaction (PCR) is a technique in modern biotechnology. A cycle of PCR consists of three principal steps, which operate at 95°C, 55°C and 72°C in sequence.

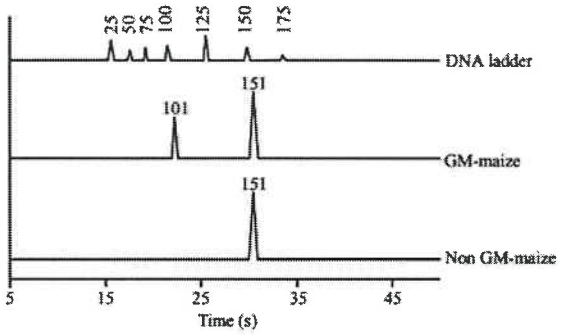
(i) Outline what happens in the three principal steps in a cycle of PCR. (3 marks)

(ii) One application of PCR is Polymerase Chain Reaction–Short Tandem Repeat Analysis (PCR–STR analysis) which can be used in forensics. In a crime scene, a piece of hair suspected to be the criminal's is found. A suspect is arrested one week later.

(1) With reference to the above case, state the significance of PCR in PCR–STR analysis. (1 mark)

(2) Describe how the products of PCR are used in PCR–STR analysis to produce evidence for verifying whether the suspect has committed the crime. (3 marks)

(iii) Another application of PCR is for identifying GM organisms. The following shows the analysis of the DNA of a GM maize and a non-GM maize:
[Note: The number above each peak in the figure indicates the number of base pairs (bp).]



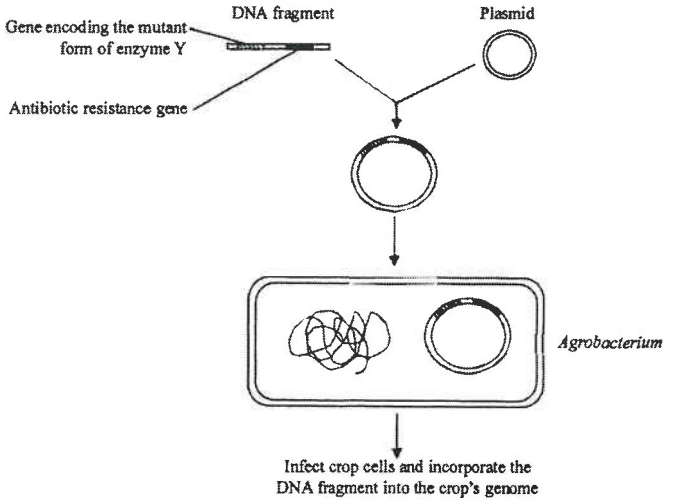
(1) A marker (a polynucleotide chain) with 101 bp is introduced to the maize in producing the GM maize. With reference to the above analysis, suggest the purpose of introducing a marker to the maize in the process of producing the GM maize. (2 marks)

(2) Illustrate with an example how GM plants can help promote people's health. (2 marks)

(3) What are the possible impacts on the ecosystem of growing GM plants that produce a toxin to kill insects? Describe **two** possible impacts. (2 marks)

4.(a) Chemical X inhibits enzyme Y in photosynthesis and kills all plants. A scientist identified a mutant form of enzyme Y that works properly in photosynthesis and is not inhibited by chemical X. He cloned the gene encoding the mutant form of enzyme Y and put it into a plasmid so that the gene can be transferred into some cells of a crop species. Figure 4A below is a diagrammatic representation of the process:

Figure 4A



(i) Describe ***two*** steps taken to put the DNA fragment into the plasmid. (2 marks)

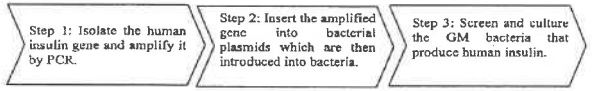
(ii) The scientist then transferred the plasmid into the cells of a crop plant using *Agrobacterium*. After the treatment, only some crop cells have incorporated with the DNA fragment.

(1) Explain why only some of the treated crop cells have incorporated with the DNA fragment. (2 marks)

(2) How can the scientist identify those crop cells that carried the DNA fragment? (3 marks)

(iii) The scientist suggests that growing this genetically modified crop together with chemical X applied to the field can greatly increase the crop yield. Explain the reasoning for this suggestion. (4 marks)

4(a) In the past, diabetic patients were treated with insulin obtained from animal pancreases. With advances in recombinant DNA technology, insulin is now derived from genetically modified (GM) bacteria. Below shows a possible scheme for developing such a GM bacterium:



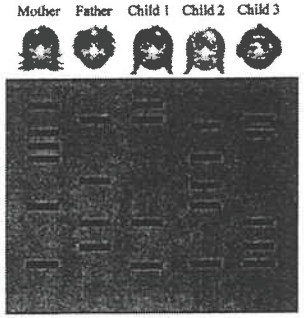
(i) Give *two* raw materials which are necessary in Step 1 for the amplification of the human insulin gene from a DNA template. (2 marks)

(ii) With reference to the immune response, **explain why insulin from GM bacteria is used instead of** that extracted from animal pancreas. (4 marks)

(iii) Explain why producing insulin from GM bacteria is cheaper than extracting it from animal pancreas. (2 marks)

(iv) To further cut the cost of insulin production, a GM crop which produces human insulin has recently been developed. However, an environmental group is worried that growing such GM crops may cause genetic pollution. Explain why growing the GM crops may cause genetic pollution. (2 marks)

4(b) The diagram below shows the DNA fingerprints of five members of a family, which consists of a couple and three children. One of the children is from the mother's previous marriage.



(i) Based on the information above, deduce which child is from the mother's previous marriage. (3 marks)

(ii) Although the other two children are the biological children of the parents shown, their DNA fingerprints display different patterns. Explain why this is so. (3 marks)

(iii) The different patterns shown in the DNA fingerprinting are due to the presence of variable number tandem repeats (VNTRs) on human chromosomes. VNTRs are short sequences of repeated DNA on the non-coding region of chromosomes and the number of VNTRs varies greatly from person to person. Explain why a large number of variations can exist in VNTRs but fewer variations are found in functional genes. (4 marks)

4(a) In the past, animals with certain desirable traits were selected to breed for several generations and the offspring produced would be domesticated. This technique is known as selective breeding. Nowadays, animals with desirable traits can be produced by animal cloning or transgenic technology.

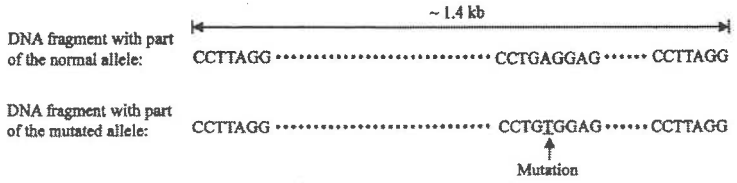
(i) With reference to the principles involved in selective breeding and animal cloning, explain why animal cloning is a better method of preserving the desirable traits of an animal than selective breeding. (5 marks)

(ii) Both selective breeding and transgenic technology affect the gene pool of a species. Transgenic technology is more controversial than selective breeding.

(1) How would selective breeding affect the gene pool of a species? (2 marks)

(2) Production of transgenic organisms is more controversial due to its effect on the gene pool of a species. Explain why. (3 marks)

4(b) DNA fingerprinting is used in the screening of a genetic disease known as sickle-cell anaemia. The disease is a result of a gene mutation which leads to the production of defective haemoglobin. To prepare the DNA fingerprint, copies of DNA fragments containing the gene associated with sickle cell anaemia are first produced by a polymerase chain reaction (PCR). The fragments are then treated by a restriction enzyme which cuts DNA at the middle of CCTNAGG, where N can be any nucleotide. The diagram below shows some nucleotide sequences of the DNA fragment containing the normal allele and the mutated allele for sickle-cell anaemia:



(i) How many restriction sites are found in the DNA fragment with the normal allele and that with the mutated allele respectively? (1 mark)

(ii) Based on the principle of gel electrophoresis, explain how the cutting of the two DNA fragments shown above would produce different DNA fingerprint patterns in a gel. (4 marks)

(iii) How many DNA bands would be observed in the DNA fingerprint of a carrier of sickle-cell anaemia? Explain your answer. (2 marks)

(iv) Explain why the gene mutation will result in the production of defective haemoglobin. (3 marks)

2015(4iii,b)

4(a) Read the following passage and answer the questions that follow it.

'Bubble kid' success puts gene therapy back on track

When Nina was a 5-week-old baby, she had a condition called severe combined immunodeficiency (SCID) which is caused by a faulty *ADA* gene. This gene originally encodes the enzyme adenosine deaminase. The absence of this enzyme will lead to the accumulation of toxins in white blood cells and finally kill the cells. Affected kids have to live in a sterile environment and they are often called 'bubble kids'.

Today, Nina is a happy girl with a functioning immune system. She has gene therapy – and its latest improvements – to thank for this. In the therapy, cells were harvested from Nina's bone marrow and given a working version of the *ADA* gene, before being injected back into her bone marrow. After 5 months, her white blood cell count had nearly doubled, and today her immune system is fully functional.

(i) With reference to the roles of white blood cells, explain why children suffering from SCID have to live in a sterile environment. (2 marks)

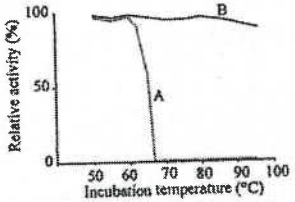
(ii) Why are cells from the bone marrow instead of white blood cells used in the gene therapy for SCID patients? (4 marks)

(iii) With reference to Nina's case, briefly describe how recombinant DNA technology is applied in gene therapy. (3 marks)

(iv) Suggest the potential hazards of gene therapy. (2 marks)

4(b) (i) Briefly describe the three major stages involved in a PCR cycle. (3 marks)

(ii) To test heat resistance of DNA polymerases A and B, the polymerases were incubated at different temperatures for 30 minutes. Their relative enzyme activities as compared to the maximum activity of the enzyme were measured. The results are shown in the graph below:



(1) Of the three stages mentioned in (i), which stage requires the action of DNA polymerase? (1 mark)

(2) Which DNA polymerase is more suitable for use in PCR? Explain your answer. (4 marks)

(iii) State *one* application of PCR. (1 mark)

2016(4b (ii, basic genetic in compulsory)

4(b) *Bt* crops were one of the early transgenic plants produced to fight against pests. They contain a *Bt* gene that produces a chemical (*Bt* toxin) which is toxic to the larvae (caterpillars) of the pest.

(i) In the production of *Bt* crops, soil bacteria are used to infect and transform the original crops. Outline the steps that should be taken to modify the soil bacterium in preparation for the infection. (4 marks)

(ii) Many scientists are concerned that the overuse of *Bt* crops will produce pests resistant to the *Bt* toxin. *Bt* resistance is a result of a mutation in the pests. The mutated allele (b) is recessive to the wild type allele (B). After feeding on *Bt* crops, only the homozygous recessive (bb) caterpillars can survive. To minimise the emergence of *Bt* resistance, scientists divided farmland into small areas, some growing *Bt* crops and others growing normal crops, as shown in the diagram below:

Key: *Bt* areas growing *Bt* crops
Non- *Bt* areas growing normal crops

(1) It was found that the mutated allele is very rare in the pest population.

(I) Compare the population size of the adult pests found in the *Bt* areas and non-*Bt* areas. (1 mark)

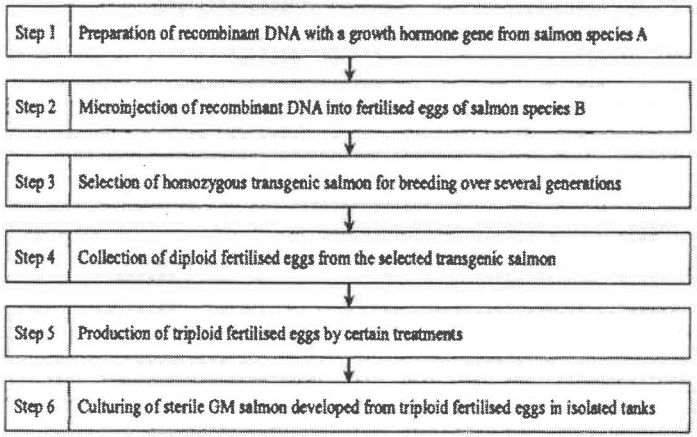
(II) State the genotype(s) of the adult pests found in the *Bt* areas. (1 mark)

(III) State the genotype(s) of the adult pests that make up the largest proportion in the non-*Bt* areas. (1 mark)

(2) (I) Explain how this strategy (growing crops in the above pattern) works in minimising the emergence of *Bt* resistance in the offspring of adult pests. (3 marks)

(II) What is the assumption behind this strategy? (1 mark)

4(a) A genetically modified (GM) salmon was approved for consumption in the United States in 2015. The flowchart below shows some simplified steps involved in the production of the GM salmon:



(i) What is the advantage of culturing this type of GM salmon over non-GM salmon? Explain your answer. (2 marks)

(ii) Microinjection method is used in step 2.

(1) Give *one* advantage of using the microinjection method instead of viral vectors for producing the GM salmon. (1 mark)

(2) Give *one* disadvantage of using the microinjection method. (1 mark)

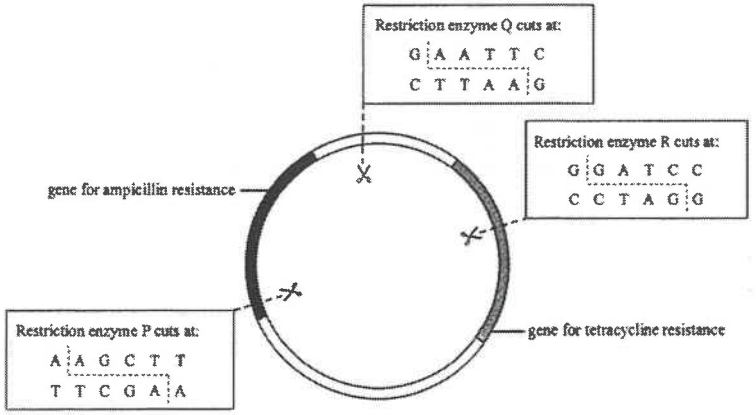
(iii) With reference to step 3, suggest *two* reasons why the selection was made over several generations rather than one generation. (2 marks)

(iv) In step 5, the triploid fertilised eggs produced contain three sets of chromosomes.

(1) With reference to the process of gamete formation, explain why the GM salmon developed from triploid eggs are sterile. (2 marks)

(2) Explain why this can act as a safety precaution for protection of wild lifes. (2 marks)

4(b) The diagram below shows a plasmid with two antibiotic resistance genes and three cut sites for restriction enzymes P, Q and R:



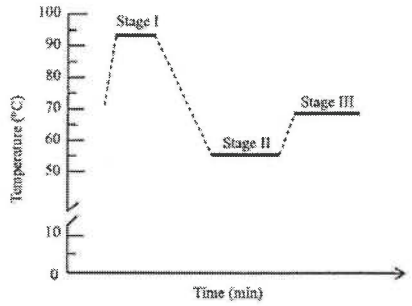
A student wanted to insert the following DNA fragment into this plasmid which was then used to transform bacteria. Only part of the nucleotide sequence of the two ends of the DNA fragment is shown:

(i) Based on the information above, choose one restriction enzyme to cut both the plasmid and the DNA fragment so that they can be successfully recombined together. Explain your answer. (4 marks)

(ii) After transformation, the bacteria were transferred to an agar plate containing ampicillin for selection. Explain the importance of this step. (3 marks)

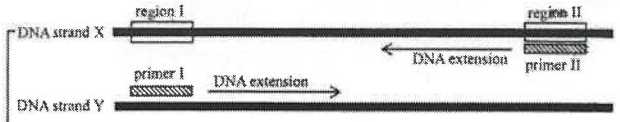
(iii) For the bacterial colonies formed on the agar plate containing ampicillin, some of them have tetracycline resistance while some do not. Explain this phenomenon. (3 marks)

4(b) The diagram below shows the change in temperature during a polymerase chain reaction (PCR) cycle:



(i) Which stage corresponds to DNA denaturation? Explain your answer. (3 marks)

(ii) Mary planned to amplify a fragment of DNA using PCR. The following diagram shows the annealing of primers during PCR. The sequence of DNA strand X is shown below and the corresponding sequences of regions I and II are highlighted:



Sequence of DNA strand X:

					no. of bases
TGGCGCTGGG	CGCAATGCGC	GCCATTACCG	AGTCCGGGCT	GCGCGTTGGT	50
GCGGATATCT	CGGTAGTGGG (region I)	ATACGACGAT	ACCGAAGACA	GCTCATGTTA	100
TATCCCGCCG	TTAACCACCA	TCAAACAGGA	TTTTCGCCTG	CTGGGGCAAA	150
CCAGCGTGGA	CCGCTTGCTG	CAACTCTCTC	AGGGCCAGGC	GGTGAAGGGC	200
AATCAGCTGT	TGCCCGTCTC	ACTGGTGAAA	AGAAAACCA	CCCTGGCGCC	250
CAATACGCAA	ACCGCCTCTC	CCCGCGCGTT	GGCCGATTCA	TTAATGCAGC	300
TGGCACGACA	GGTTTCCCGA	CTGGAAAGCG	GGCAGTGAGC	GCAACGCAAT	350
TAATGTGAGT	TAGCTCACTC	ATTAGGCACC	CCAGGCTTTA	CACTTTATGC	400
TTCGGCTCG	TATGTTGTGT	GGAATTGTGA (region II)	GCGGATAACA	ATTTCACACA	450

Mary designed the following primers for the PCR:

Primer I: CGGUAGUGGG AUACGACGAU DNA extension →

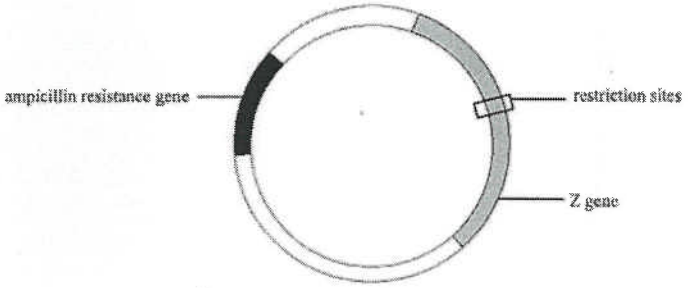
Primer II: CCTTAACACT CGCCTATTGT DNA extension →

(1) There is one type of mistake in each primer. Write the correct primers to be used. (2 marks)

(2) What is the predicted size (in terms of number of base pairs) of the PCR product? (1 mark)

(iii) Mary used the following plasmid as a vector to carry the PCR product to transform bacteria. The plasmid contained:

(I) an ampicillin resistance gene;
(II) a Z gene encoding an enzyme that converts substance X to blue compounds;
(III) some restriction sites within the Z gene.

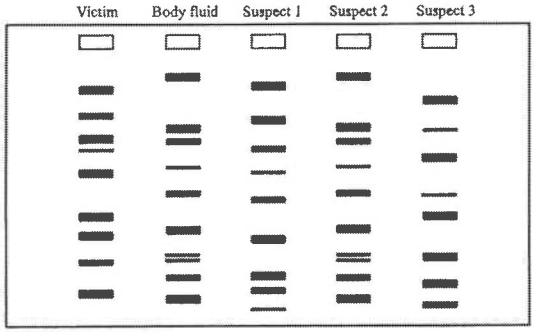


After the transformation of the bacteria, Mary grew the bacteria on agar plates containing both ampicillin and substance X. Blue and white bacterial colonies were formed.

(1) What is the purpose of adding ampicillin to the agar plates? Explain your answer. (2 marks)

(2) Explain which type of colony (blue or white) contains non-recombinant plasmids, i.e. without DNA insert. (4 marks)

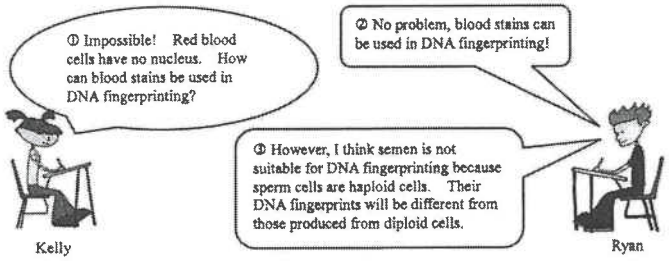
4(a) Samples of body fluids or cells collected from crime scenes can be examined with VNTR-based DNA fingerprinting. The diagram below shows the DNA fingerprints of body fluid samples collected from a crime scene, and those of the victim and three suspects:



(i) Based on the above results, deduce who is most likely the criminal among the three suspects. (1 mark)

(ii) Explain why the DNA fingerprints of these suspects showed different patterns. (3 marks)

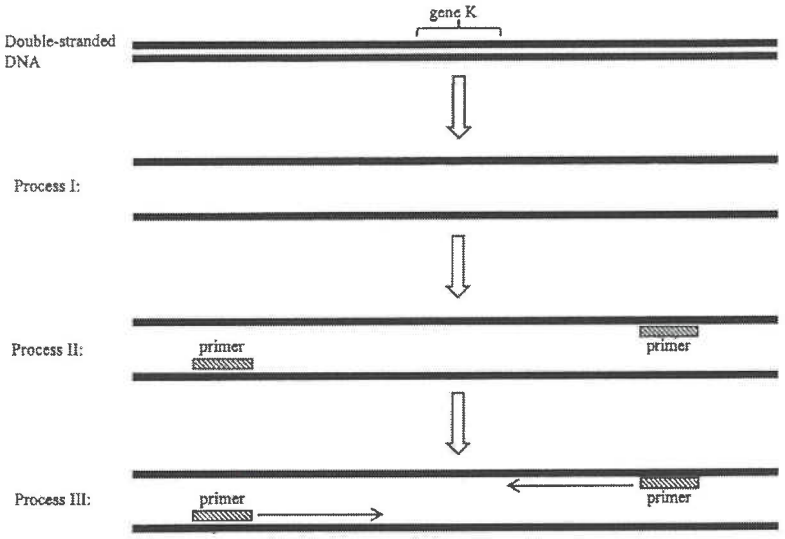
(iii) Semen and blood stains are body fluid samples which can be collected from crime scenes. Kelly and Ryan disagree about the suitability of using these body fluid samples for DNA fingerprinting. Below is their conversation:



(1) Is Kelly or Ryan right about whether blood stains can be used for DNA fingerprinting? Explain your answer. (2 marks)

(2) Do you agree with Ryan's comment about the suitability of using semen for DNA fingerprinting? Explain your answer. (4 marks)

4(b) A scientist discovered a bacterial species capable of secreting a protein. This protein is toxic to insects that damage the roots of a certain crop. The protein is encoded by gene K. The scientist used polymerase chain reaction (PCR) to amplify gene K. The diagram below shows some PCR processes:



(i) What is Process II? (1 mark)

(ii) Draw a simple labelled diagram to show the expected PCR product. (2 marks)

(iii) Primers often contain about 18–22 bases. If primers with fewer bases are used, PCR products of different sizes are obtained. Explain this phenomenon. (2 marks)

(iv) The scientist wanted to transfer gene K into the crop by using *Agrobacterium* (a soil bacterium). Explain why *Agrobacterium* is suitable for transferring the target gene into the crop. (2 marks)

(v) The cultivation of this transgenic crop was found to produce higher yields than its non-transgenic counterpart. Suggest an explanation for this. (3 marks)

4(a) Study the diagrams below. Diagram X shows a DNA segment with a target gene. Diagram Y shows a plasmid with a size of 4 300 base pairs (bp). The restriction sites for restriction enzymes EcoRI, PstI and HindIII are shown in both diagrams.

Diagram X

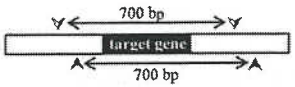
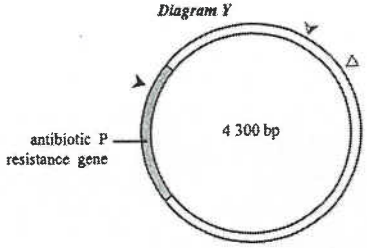


Diagram Y



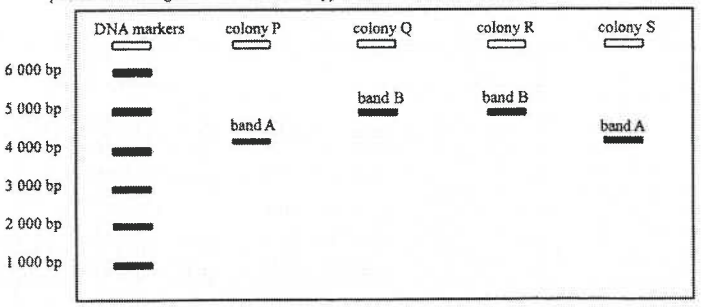
Key: ⩛ restriction site for EcoRI
⩛ restriction site for PstI
▽ restriction site for HindIII

(i) A student plans to insert the target gene into the plasmid and screen the transformed bacteria with antibiotic P.

(1) Which restriction enzyme should be used for the insertion? Explain your answer. (3 marks)

(2) State another type of enzyme which is required to complete the insertion. (1 mark)

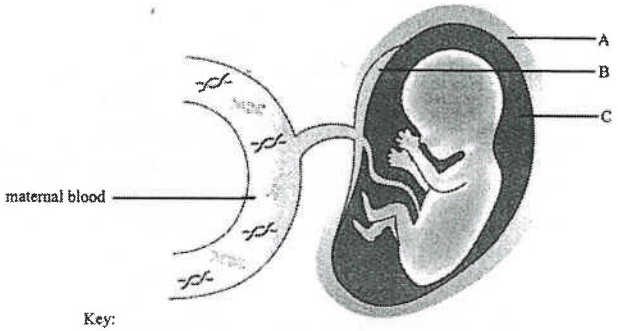
(ii) After transformation, screening and culture, the plasmids from different colonies were harvested and cut using enzyme HindIII. Gel electrophoresis was then conducted to check the size of the cut plasmids. The diagram below shows two types of DNA band obtained:



(1) Which band (A or B) represents the plasmids with the target gene? Explain your answer. (3 marks)

(2) Explain why two types of DNA band were detected in the cut plasmids after gel electrophoresis. (3 marks)

4(b) Traditional diagnosis of Down Syndrome requires the collection of foetal tissue. The recent discovery of cell-free foetal DNA in maternal blood has opened up new possibilities for diagnosis. Cell-free DNA are fragments of DNA released into the plasma from the degradation of normal cells. The diagram below shows a foetus and its associated structures inside the mother's body:



Key: cell-free maternal DNA cell-free foetal DNA

(i) With reference to the above diagram, which labelled structure does the cell-free foetal DNA come from? Explain your answer. (2 marks)

(ii) In the maternal plasma, cell-free foetal DNA is only a minor proportion of the total cell-free DNA. Suggest a technique for enhancing the detection of very small amounts of cell-free foetal DNA in maternal plasma. Explain your answer. (2 marks)

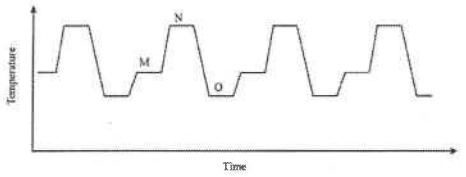
(iii) Nowadays, the identity of the genes in the cell-free DNA can be found through DNA sequencing and mapping against human genome databases.

(1) Scientists proposed that Down Syndrome could be diagnosed by comparing the frequency of occurrence of the genes found on chromosome 21 and another autosome in the cell-free foetal DNA. Based on your understanding about Down Syndrome, explain the biological principle involved in this method. What would be the expected results? (2 marks)

(2) **Suggest *two* other possible applications of the results obtained from DNA sequencing.** Explain the principle of each application. (4 marks)

4(b) In the production of genetically modified organisms (GMO), antibiotic resistance genes are often used for the screening of successful transformation. A student collected some food products and wanted to determine if these food products are made from GMO. With primers corresponding to these antibiotic resistance genes, the student performed a polymerase chain reaction (PCR) on the food samples to check for the presence of the genes.

(i) The graph below shows the change in temperature during PCR cycles:



(1) Which stage (M, N or O) represents annealing? With reference to the events in a PCR cycle, explain your answer. (3 marks)

(2) Draw a simple labelled diagram to show what happens in the annealing stage. (2 marks)

(ii) The diagram below shows part of the DNA sequence of an antibiotic resistance gene X. The sequences shown are the corresponding regions for primer annealing:

Direction of primer extension

... GGATCAGCTG ACTCGCCTGG ..... CACGCGGAGG AGCGTCCGCG ...

600 base pairs

Which of the following primers (I, II, III or IV) should be used for amplifying gene X? (2 marks)

Primer I: GGTCCGCTCA GTCGACTAGG
Primer II: CCTAGTCGAC TGAGCGGACC
Primer III: GTGCGCCTCC TCGCACGCGC
Primer IV: GCGCGTGCGA GGAGGCGCAC

(iii) Describe how you can use the principle of gel electrophoresis to confirm if the PCR product is gene X. (3 marks)

Human impacts on the environment
2012pp(2a)

2.(a) (i) Mark-and-recapture method (e.g. mark the birds at the site in Canada by putting specific rings on the legs of the birds and check if the ringed birds be retrieved at the wintering ground in the U.S.A.) / Installing a GPS tracking device on the birds 1

(ii) (1) The average January temperature in the U.S.A. shows an increasing trend. 1

(2) The bird species have shifted their winter destination farther north as these areas have become warmer. 1
As the northern part becomes warmer, the birds can find a suitable habitat with adequate food supply for wintering without flying farther south. 1

(3) The migratory bird species may
- compete for food / territory with native bird species. 1
- become the prey of native bird species and this may lead to a growth in the population of the native birds. 1

(Accept other correct alternatives.)

(4) The atmospheric concentration of carbon dioxide / methane (greenhouse gases) has been increasing 1
due to the increasing consumption of fossil fuels *(for stating carbon dioxide as the greenhouse gas)* /rearing of livestock or decomposition of increasing amount of organic waste dumped in landfills *(for stating methane as the greenhouse gas)*. 1
When the Earth surface emits (the) radiation (it absorbs from the sun) into the atmosphere, the radiation is trapped / absorbed by the greenhouse gases and warms the atmosphere. 1
This leads to global warming and thus the increase in the average January temperature. 1

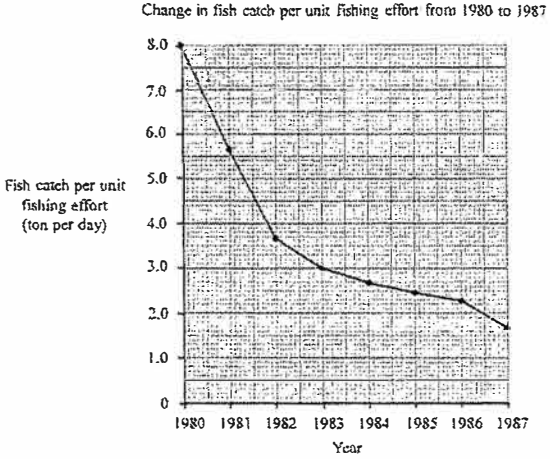
2012sp(2a)

2.(a) (i)

Year	Fish catch per unit fishing effort (ton per day)
1986	2.25
1987	1.67

(1 or 0)

(ii) Title (½) (3)
Correct choice of axes (½)
Correct labelling of axes with units (1)
Correct plotting and joining of points (1)



(iii)
- the fish catch per unit fishing effort decreased from 1980 to 1987 (1) (3)
- because the fishing effort increased much faster than the total fish catch in these years (1)
- this is probably due to over-fishing (1) / the fish population in the sea is a limited resource

(iv) Any two of the following: (accept other reasonable alternatives) 2 x (1, 1)
- restrict the mesh size of fish net (1), so that smaller or juvenile fish can escape from being caught and can grow to sexual maturity (1) (4)
- ban fishing activity for a period of time in a year, especially during the spawning season (1) to allow recovery of the population (1)
- set a quota on the fish catch per fishing trip (1) / restrict the size of fishing boat / the capacity of fishing gear, so that the rate of fish catch does not exceed the rate of recovery of the fish population (1)
- designate some 'no-take' zones (1) in the sea to provide protected areas for the breeding of fish (1)

Total: 11 marks

2012(2)

2. (a) (i)
- ecological succession takes place at Stage II where the land will be first conquered by fast-growing plants / low nutrient-requiring plants such as ferns / grasses (1) (1)
- the death and decay of these plants increase the soil fertility (1) (1)
- the soil becomes suitable for shrubs / trees to grow and become the dominant species (1), restoring the land (1)

(ii) the runoff from Stage I is higher than that from Stage III (1) because: (1)
- frequent ploughing destroys soil texture of the land (1), as a result, there are more soil cavities for leaching (1) (1)
- harvesting / removal of crops from the land reduces the return of organic matter to the soil (1), as a result, there are less humus to retain soil water (1) (1)

(iii)
- lacking of magnesium / nitrogen (nitrate) will result in yellowing of leaves (1) (1)
- because the crops cannot synthesize chlorophyll with this nutrient / this nutrient is necessary for the formation of chlorophyll (1) (1)

(iv)
- some soil nutrients dissolve in water and lose together as runoff (1) (1)
- some soil nutrients are attached to soil particles which are washed away by the runoff (1) (1)

(b) (i)
- the AR increases the number of fish species (1)
- until it becomes stable after year 8 (1)
- whereas there is no obvious change in the number of fish species at the sandy seabed area (1) (max. 3)
- the number of fish species in the AR site is greater than that at the sandy seabed area (1)

(ii)
- AR provides different habitats with different characteristics / biotic and abiotic factors (1) and these attract new species to stay because
  - there are suitable shelters for fish to hide from predators / survive / live and grow (1)
  - there are suitable spawning grounds for fish to breed and reproduce (1) (max. 3)
- as the biodiversity increases, it further attracts other predatory fish species to come and feed on smaller fish (1)

(iii) Any *two* of the following:
- the materials should be nontoxic to prevent lethal and sublethal effects on / killing of the living organisms (1)
- the materials should be durable / long-lasting to increase the life span of the AR / for a ten-year study (1) (max. 2)
- rough surfaces / more cavities that allows the settlement of the larvae of corals / create more microhabitats (1)

2014(2b)

(b) (i)
- location A (1)
- highest percentage cover by live corals and lowest percentage of dead corals (1) (2)

(ii) (1)
- sewage discharge from farms (1)
- release large amount of inorganic nutrients including NO_3^-/ PO_4^-
- (1) which favour / induce fast growth of seaweeds (1) (3)

(2)
- the seawater is polluted and no longer suitable for growth of corals / seaweed outcompete corals for space or light / seaweed produced toxic substances that kill corals (1) (1)

(iii) (1)
- corals provide shelters (1)
- and food sources for other marine organisms (1) } any two points (1,1)
- and breeding ground for other marine organisms (1)
- which attracts many other marine species to settle there (1) (1)

(2)
- destructive fishing such as trawling / yachting / water skiing (1) (accept other reasonable answers) (1)

2016(2b)

(b) (i)
- arsenic reduced the growth of both plant body and grain in the contaminated soil (1)
- with a greater reduction in the growth of grain (1) (2)

(ii)
- for grains, phosphate addition increased growth under both contaminated and uncontaminated soil (1)
- with growth in uncontaminated soil better than that in contaminated soil (1)
- for plant body, addition of phosphate did not improve the growth in the uncontaminated soil but improved the growth of plant body in contaminated soil (1)
- to values comparable to that in uncontaminated soil with no addition of phosphate (1) (4)

(iii)
- phosphate addition increased the accumulation of arsenic in plant body (1)
- but decreased that in grains (1) (2)

(iv)
- addition of phosphate care improve yield of wheat (1), i.e. grains
- and reduce health risk by reducing the uptake of arsenic in grains (1) (2)

2017(2)

2. (a) (i)
- stir up sediments or pollutants at sea bottom / turbidity of water increases (1)
- destruction of habitats / shelters / breeding grounds at sea bottom (1) (2)

(ii) (1)
- sites A and C > sites B and E > sites D and F (1)
- this shows that the closer the site to the protected area, the higher the animal biomass / the further the site to the protected area, the lower the animal biomass (1) (2)

(2)
- protected area is undisturbed by fishing, thus providing a breeding ground for marine animals / at non-protected area, fish or marine animals are constantly caught (1)
- therefore, the marine protected area has more food resources as indicated by the highest animal biomass at sites A and C (1)
- some of them have migrated to the adjacent area (1), resulting in higher animal biomass in sites B and E than that sites D and F (3)

(iii)
- animal biomass only indicates the total amount of biological / organic materials of all the species (1)
- it cannot reflect the impact on individual species (1)
- this can be rectified by counting the total number of species (1)
- to show the impact on biodiversity of the protected area as well (1) (4)

(iv)
- Hoi Ha Wan Marine Park / Yan Chau Tong Marine Park / Sha Chau and Lung Kwu Chau Marine Park / Tung Ping Chau Marine Park / Cape D'Aguilar Marine Reserve / The Brothers Marine Park (1) (Any one) (1)

(b) (i)
- Because the provision of food / nutrients from Zooxanthella has been cut off (1) (1)

(ii)
- the heat / infra-red radiation reflected from the earth (1)
- is trapped by carbon dioxide in the atmosphere (1)
- hence increases the atmospheric temperature (1) and hence the water temperature increases (3)

(iii) (1)
- increased water temperature resulted in a greater health deterioration in native corals than transplanted corals (1) as reflected by (*any two*)
  - more healthy cases in transplanted corals than in native coral (1)
  - more bleached cases in native coral than in transplanted coral (1)
  - more dead cases in native coral than in transplanted coral (1) (3)

(2)
- thermal tolerance of the corals can be enhanced by exposing them to higher temperatures / corals may gradually adapt to the rise in seawater temperature (1) (1)

2019(2b)(more about biodiversity in compulsory part)

(b) (i) Any *two* of the following: (2)
- soil erosion / soil degradation / desertification (1)
- loss of habitats / fewer shelters (1)
- decrease in biodiversity / decrease in plant community (1)

(ii) (1)
- the dry mass of Species B increased more significantly than that of Species A with the addition of fertilizer (1)
- the concentration of heavy metal X was higher in the root of species B (1)
- with the addition of fertilizer, the concentration of heavy metal X in the root was enhanced (1)
- resulted in a much larger accumulated amount of heavy metal X in the root (1)

(4)

(2)
- species B (1)
- a lower concentration of heavy metal X in shoots may cause less health problem to herbivores that consume shoots / consumers along the food chain (1)

OR
- species C (1)
- the shoots can be harvested to remove heavy metal X from the site (1)

(2)

(3) Any *two* of the following:
- growing native species can develop a plant community which is similar to the original community / will not affect the structure of the native community / non-native species may outcompete the native species that can affect the structure of the original community / minimize the disturbance to local ecosystem (1)
- native species are well adapted to the local environment (1)
- native species provide food/ habitats for local animals (1)

(2)

Pollution control and conservation

2012pp(2b)

2.(b) (i) Any two of the following sets of answers: 2 x 2
- Acid rain deposited in water bodies decreases the pH, which may kill organisms that are sensitive to acidity. (1) This reduces the populations of specific species in the habitat. (1)
- Acid rain enhances the release of aluminium ions from soil which are toxic to plant roots. (1) This reduces the population size of plants / reduces biodiversity. (1)
- Acid rain reduces soil fertility / dissolves soil nutrients and facilitates their loss through leaching. (1) This reduces plant productivity. (1)

[For each set of answer, 1 mark is for the cause leading to the impact and 1 mark is for the impact.]

(ii) Logging removes the biomass above the forest floor. 1
Forest B will reestablish more quickly after logging 1
because it retains a greater proportion of nutrients in the roots and soil below the forest floor. 1

(iii) (1) Any one of the following: 1
- Biodiversity provides us with a variety of useful materials for human use directly (e.g. food) or indirectly (e.g. wood products).
- Biodiversity helps maintain the stability of an ecosystem / recovery of an ecosystem after disturbance.
- Biodiversity provides biological resources (e.g. breeding stocks, population reservoirs, gene pools) for scientific research / education.
- Biodiversity provides recreational service to humans (e.g. ecotourism).

(2) Any one of the following criteria: 1
- capable of establishing themselves in damaged land
- fast-growing

(Accept other correct alternatives.)

Any one of the following disadvantages: 1
- lack of biodiversity in the plantation
- the plantation may quickly be destroyed as the spread of diseases / parasites specific to it will be quick
- depletion of specific soil nutrients

(Accept other correct alternatives.)

2012sp(2b)

2.(b) (i)
- as light is absorbed / scattered / reflected when it passes through water, the light intensity decreases with water depth (1)
- thus the rate of photosynthesis decreases (1) with increasing water depth

(2)

(ii)
- lake A (1)
- this is because much higher photosynthetic rate is found in the subsurface water in lake A (1) and this indicates that more nutrients are available to encourage the growth of the producers in this lake (1)

(3)

(iii)
- lake A (1)
- in the daytime the net photosynthetic rate of lake . Ais much higher than that of lake B; this implies that the net oxygen production by phytoplanktons in lake A will be greater than that in lake B (1)
- at night, the great phytoplankton population in lake A (1) will have much greater oxygen consumption in respiration, thus reducing the dissolved oxygen to a lower level (1)

(4)

2013(2)

2. (a) (i)
- acid rain / acidic water retards the growth of bean seedlings (1)
- presence of heavy metal X in the soil retards the growth of bean seedlings (1)
- least growth occurs under the combined effect of low pH and heavy metal X (1)

(3)

(ii)
- acid rain releases the heavy metal ions X in the soil (1)
- therefore there is a higher concentration of heavy metal ions X in the soil (1)
- resulting in a greater effect of inhibition on the growth of bean seedlings (1)

(3)

(iii)
- sulphur dioxide (1) and nitrogen oxides (1) from the burning of fossil fuels
- these acidic gases may cause irritation to eye / respiratory tract (1)

(3)

(b) (i)
Any three of the following:
- high fat solubility (1)
- cannot be metabolized easily / non-biodegradable (1)
- cannot be excreted (1)
- stable and persistent (1)

(max. 3)

(ii)
- birds (1)
- highest amount of pollutant Y was detected in birds (1)
- since the top consumers feed on a large number of organisms at the lower trophic levels, they usually have the highest amount of heavy metal ions accumulated / since the pollutant is accumulated along the food chain, the top consumer has the highest level of the pollutant (1)

(3)

(iii)
- producers (1)
- capture solar energy and turn it into its biomass / chemical energy (1)
- this provides food / energy source to other organisms in the ecosystem (1)

Or
- decomposers (1)
- break down organic matters into inorganic matters (1)
- this allows the cycling of materials in the ecosystem (1)

(3)

(iv)
- liver (1)
- because it is the organ responsible for detoxification, thus toxic substances are captured and metabolised / processed there (1)

(2)

2014(2a)

2. (a) (i) (1)
- concentration of pesticide at which 50% of the crustaceans are killed:
  A: 42 $\mu g\ L^{-1}$
  B: 27 $\mu g\ L^{-1}$

(1)

(2)
- as the 50% mortality occurs at a lower concentration of B than A (1)
- showing that pesticide B is more toxic (1)

(2)

(ii) (1)
- pesticide B is more readily absorbed than pesticide A (1)
- pesticide B is less readily excreted than pesticide A (1)
- pesticide B is less readily degradable / metabolized / broken down than pesticide A (1)

(3)

(2)
- to ensure no mortality is observed throughout the experiment (1)

(1)

(iii)
- carnivorous fish is expected to have a higher concentration of pesticide A than herbivorous fish (1)
- because carnivores occupy a higher trophic level than herbivores (1) / carnivorous fish has a higher trophic level than herbivorous fish
- animals at a higher trophic level accumulated more pesticides when they feed on organisms at lower trophic levels / animals at a higher trophic level accumulated more pesticides along the food chain (1)

(3)

2015(2)

2. (a) (i)
- carbon dioxide traps / absorbs heat radiation reflected from ground (1)
- leading the an increase in the atmospheric temperature (1)

(2)

(ii)
- carbon dioxide is a raw material for photosynthesis (1)
- an increase in atmospheric carbon dioxide concentration will result in an increase in the overall photosynthetic rate (1)
- hence, more carbon dioxide will be absorbed (1) to counteract the increase

(3)

(iii) (1)
- stomatal density of plants decreases with an increase in atmospheric carbon dioxide concentration (1)
- as a result, it will reduce the rate of gas exchange in plants (1)
- this offsets the effect of increase in carbon dioxide concentration / this reduce the uptake of carbon dioxide from the atmosphere (1)

photosynthetic rate may not increase to the expected extent

(3)

(2)
- a decrease in stomatal density will reduce the transpiration in plants (1)
- this will reduce precipitation (1) / less condensation / less rainfall

and hence the regional climate will be altered

(2)

(b) (i) (1)
- dissolved oxygen content decreases as water flows from location 1 to location 2 (1)
- because sewage contains a large amount of organic matter (1)
- microorganisms downstream consume dissolved oxygen (1)
- for the decomposition of the organic matter (1)

(4)

(2)
- as dissolved oxygen content is very low at location 2, active animal species die of suffocation / migrate to other region of the river (1)
- only hypoxia tolerant species (low-oxygen tolerant species) can survive at location 2 (1)

(2)

(ii) (1)
- as organic matter has been used up, decomposition activity decreases / less microorganisms carry out decomposition (1)
- oxygen continues to dissolve in the stream water due to running water / photosynthesis of aquatic plants (1)

(2)

(2)
- the biotic and abiotic properties of Location 3 are different from those of Location 1 (1) / different habitats
- Such as the rate of water flow is slower in Location 3 / there are shadings / fallen leaves from trees nearby (1)

(2)

2016(2a)

2. (a) (i)
- water sample B is household sewage which contains a large amount of organic matters (1)
- microorganisms in water decompose these organic matters (1)
- hence, oxygen in water sample B is consumed more quickly than that of water sample A (1)
- therefore, water sample B (residential area) has a higher BOD than that of water sample A (industrial area) (1)

(4)

(ii)
- water sample A shows that the site has been polluted with heavy metals (1)
- heavy metal cannot be excreted / broken down metabolically / detoxified (1)
- therefore, it will be accumulated along the food chain and reach a certain amount in the bodies of consumers such as fish (1)
- hence, people consume fish from river nearby industrial area may suffer from heavy metal poisoning (1)

(4)

(iii) (1)
- antibiotics are excreted together with the urine / unabsorbed antibiotic are egested together with feaces by the people in the residential area (1)

(1)

(2) Any *one* of the following:
- natural microorganisms may develop antibiotic resistance, some of which may be pathogenic to humans / may cause other ecological effects (1)
- natural microorganisms may be killed by the antibiotic residues and thus disturb ecological balance (1)

(1)

2018(2)

2. (a) (i) (1) • Cadmium = 1.2 /0.6 = 2 (1) (1)

(2) • when the ratio is greater than 1, it means there is accumulation / magnification of heavy metal / cadmium in the body of the consumer / bivalve (1) (1)

(3) • the ratio for cadmium is higher than that of copper (1) because
Any *two* of the following:
- copper is more readily excreted than cadmium, or vice versa (1)
- copper is more readily detoxified / metabolised than cadmium, or vice versa (1)
- copper is less readily soluble in fat than cadmium, or vice versa (1)

(3)

(ii) • keep the same / similar number of bivalves at different concentrations of cadmium (1)
• for a fixed period of time (1)
• record the percentage of death / no. of death / mortality / mortality rate at the end of the experiment (1) (3)

(iii) • Any reasonable answers that apply the 3R principles of (reduce, replace, recycle) (2)

(b) (i) • increasing the amount of organic pollutants increases the carrying capacity of the habitat / the food supply to the invertebrates (1)
• hence, the birth rate is greater than the death rate / reproductive rate increases / this attracts other invertebrates to move to this area (1), i.e. the community is expanding (2)

(ii) (1) • the biomass of the community is decreasing (1)
• while the abundance / total number of organisms is increasing (1)
• this indicates that the body size of the organisms in the community is decreasing (1), i.e. the proportion of larger invertebrates is declining (3)

(2) • microbial decomposition of such a large amount of organic pollutants consumes / depletes a large amount of oxygen in the seabed (1)
• larger invertebrates have higher oxygen demands than smaller invertebrates (1)
• they die due to suffocation / they migrate to other places (1) (3)

(iii) • the number of species continues to drop (1) (1)

(iv) • very small / high turnover rate / anoxia tolerance / high pollution tolerance (any one) (1)

2019(2a)

MARKS

2. (a) (i) • large solid wastes are removed by passing through screens / filters (1)
• suspended solid wastes in sewage settled down by sedimentation and removed (1) (2)

(ii) (1) • the effluent of sewage treatment plant had a lower organic nitrogen content than that of the artificial wetland (1) because
• sewage was aerated in sewage treatment plant (1)
• to enhance the activities / growth of microorganisms (1)
• the conversion / decomposition of organic nitrogen to ammonium compounds in sewage treatment plant is faster (1) (4)

(2) Any *one* of the following sets:
- presence of phosphate (1), as a raw material for the synthesis of DNA / RNA / ATP / NAD / NADP / phospholipids (1)
- presence of magnesium (1), as a raw material for the synthesis of chlorophyll (1) (2)

(iii) Any *two* of the following:
- lower cost of construction/ equipment than that of sewage treatment plant (1)
- the artificial wetland is self-sustaining / no extra manpower needed / lower running cost (1)
- the artificial wetland is effective enough for small village with limited sewage (1) (2)