Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2017

Environmental systems and societies

Standard level

Paper 2

18 pages

Section A

1. (a) State the main source of energy for the food chain in **Figure 1**. **[1]**

Sun/sunlight/insolation/solar energy;

(b) State the trophic level labelled **X** in **Figure 1**. **[1]**

(primary) producer / autotrophs / phototrophs / phytoplankton / green plants;

The command term "State" requires a "specific name" so do not credit "trophic level 1".

(c) Identify **one** use of DDT leading to its presence in the environment. **[1]**

insecticide/pesticide / kill pests/insects / control malarial mosquitoes / plague / ***OWTTE***;

(d) With reference to the concepts of bioaccumulation **and** biomagnification, outline how the concentration of DDT has changed along the food chain. **[2]**

bioaccumulation: DDT absorbed by a given trophic level is not broken down/excreted / is non-biodegradable so accumulates in tissues; ***[1]***

biomagnification: the concentration of DDT will increase as it's passed along/up food chain (because other biomass is lost); ***[1]***

Do not allow simply "organisms at higher levels eat/consume more". Higher trophic levels do not consume more biomass in a given time than lower trophic levels.

(e) (i) State the relationship between large and small fish in **Figure 1**. **[1]**

predator-prey / carnivory / predation / ***OWTTE***;

Do not credit "small fish are eaten/consumed by large fish".

(ii) Outline how this relationship may be of benefit to the populations of both species. **[2]**

the predator benefits by gaining food from prey / its population is limited/stabilized by amount of prey available; ***[1]***
they prey benefits by predators limiting/stabilizing its population / selecting out weaker/diseased individuals / maintaining healthy gene pool in prey / reducing competition in prey for available food/resources; ***[1]***

Award full marks is response describes negative feedback between both populations, or indicates that each group regulates population of the other.

2. (a) State the crop which is under the greatest water stress. **[1]**

cotton;

(b) Identify **two** strategies that could be used to grow crops in water stressed areas. **[2]**

improved irrigation efficiency *eg* drip irrigation;
use crop cultivars that require less water (*eg* drought resistant seeds/GMOs) / replace high stress crops (*eg* cotton) with low stress (*eg* oats);
improve water catchment/storage with dams; reservoirs;
install desalinization plants in coastal areas;
plant cover crops/use terracing (to reduce evaporation/run-off losses);
use salt-tolerant crops to exploit available sea-water/saline soils;

Do not credit simply "irrigation". Too vague.

(c) Identify **three** factors that may lead to an increase in water stress for a given agricultural area. **[3]**

increased demand through increased population / domestic/agricultural/industrial use;
increased water consumption through more affluent lifestyles / shift to meat-rich diets;
move towards more intensive agriculture/irrigation / unsustainable abstraction of water;
movement of water out of drainage basin *eg* aqueducts / upstream use by other countries;
growing of inappropriate/heavily water-dependent crops;
deforestation in drainage basin / pollution/contamination of water sources;
drought/reduction of rainfall (due to global warming/El Niño);

*Award **[1]** for each correct factor identified, up to **[3 max]**.*
For last MP, do not accept simply a description of a regular climate eg low rainfall/dry season. The question asks for what will increase stress, so there needs to be a suggestion of change.
Marking points above may be stated as given or explicitly demonstrated through reference to examples/case studies (eg cotton around Aral Sea absorbs excessive water from an environment at risk).

3. (a) Calculate the projected percentage increase from 2007 to 2030 in CO_2 emissions for Russia. **[1]**

$\left(\frac{4 \times 100}{11.7} =\right)$ 34 % increase (allow 32–36 %);

(b) Outline how CO_2 emissions can cause a change in the global climate. **[2]**

emissions (lead to higher concentration) of CO_2 which is a greenhouse gas;
…causing greater absorption of infra-red/heat radiation and rise in global temperature;
…leading to increased evaporation/changing winds/shifting patterns of precipitation/droughts/extreme weather events/storms/hurricanes/El Niño;

(c) Identify **two** possible reasons for the projected change in CO_2 emissions for China. **[2]**

growing number of fossil-fuelled vehicles/transport;
rapidly advancing economy/standard of living;
increase in fossil-fuelled power plants / increased industrialization;
increase in intensive/mechanized farming systems (in place of traditional);
burning of forests to clear land for agriculture;

Accept any other reasonable suggestions.
*Award **[1]** for each correct reason identified, up to **[2 max]**.*

(d) Identify **one** reduction strategy that the United States may use to achieve its projected change in CO_2 emissions. **[1]**

reduction of energy consumption/CO_2 production through laws/taxes/education;
use of alternatives to fossil fuels;
CO_2 removal though CCS;
afforestation / reducing rates of deforestation;

Accept any other reasonable suggestions, but they must be explicitly linked to reduction in C emissions ie not simply "improve public transport" or "recycling".

(e) Identify **one** adaptation strategy that could be used to reduce the impacts of climate change. **[1]**

flood defences (*ie* levees/dikes);
desalinization plants to replace freshwater losses;
planting of crops in previously unsuitable areas;
water conservation (*eg* restrictions on use of irrigation/sprinklers);
exploiting areas that have become more productive for crops through climate change;
developing (*eg* drought-resistant) crops better adapted to areas impacted by climate change;
green roof system that cools the building through evapotranspiration/reflection;

Accept any other reasonable suggestions.
Some strategies can be acknowledged as both adaptive and mitigating eg a "green roof" both reduces impact of climate change by cooling the building (adaptation) and reduces cause of climate change by reducing C emission (mitigation). Such suggestions should not be credited unless the link to reducing impact is made clear, as in the last MP above.

(f) Explain how the ability to implement mitigation and adaptation strategies may vary from one country to another. **[4]**

political will/pressure for change may differ due to some countries being more/less committed to their industrial lifestyles/economic growth / inhibited through political corruption;
finance/economics may/may not allow some countries to fund new technologies/infrastructures;
some countries may depend upon others for knowledge transfer/technological assistance to implement resolutions;
religious/political/cultural norms/education in some countries may promote/limit their perception of environmental threats/approach to management;
geographical location of some countries may place them at greater/more immediate risk from impacts of climate change (*eg* low-lying islands/tropical storm-prone nations) / or offer them greater opportunities for mitigation (*eg* available sources of alternative energy);
some countries may perceive greater immediate priorities *eg* war in Syria/poverty in Somalia;

*Award **[1]** for each correct explanation, up to **[4 max]**.*
Accept other valid explanations of equivalent validity.
Do not accept eg "Economics" alone without an explanatory note as in MPs above.

Section B

Part (c) questions in Section B are all to be assessed using the markbands on page 18 with the guidance given below for each question.

4. (a) Identify **four** ways in which solar energy reaching vegetation may be lost from an ecosystem before it contributes to the biomass of herbivores. **[4]**

reflected from the leaf surface;
absorbed by non-photosynthetic surface;
heat/some wavelengths are absorbed by leaf but not used in photosynthesis/not converted into chemical energy;
(chemical energy/GPP) respired by vegetation;
(chemical energy/GPP) not eaten/harvested by consumer / dead material consumed by decomposers;
eaten but not absorbed by herbivore / lost in faeces;
absorbed by herbivore, but lost through respiration;

*Award **[1]** for each correct way identified, up to **[4 max]**.*

(b) Suggest a series of procedures that could be used to estimate the net productivity of an insect population in kg m^{-2} yr^{-1}. **[7]**

measure change in population size over year;
using Lincoln Index/mark-release-recapture;
set traps/capture a sample, mark and release them;
re-set traps for a second capture and calculate the proportion marked and unmarked;
use the equation: $N = \frac{n_1 \times n_2}{n_3}$;
weigh a sample of insects to find (wet) weight;
use a conversion factor to calculate dry weight from (wet) weight;
calculate mean dry weight/biomass per individual;
from mean dry weights and population sizes calculate total weight change over year;
estimate area occupied by population using measuring tapes/scale maps;
divide total change in dry mass by area in m^2;

*Award **[1]** for each correct suggestion, up to **[7 max]**.*
Credit any alternative sequence of procedures that is equally appropriate to finding net secondary productivity eg using lab population and weighing dry weight of food, faeces, respiration rates, etc, awarding marks similarly to scheme above.

(c) To what extent are the concepts of *net productivity* and *natural income* useful in managing the sustainable harvesting of named resources from natural ecosystems? **[9]**

*The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria given in each of the markbands (although "ESS terminology" has been conflated with "Understanding concepts"). This guide simply provides some **possible** inclusions and should not be seen as requisite or comprehensive. It outlines the kind of elements to look for when deciding on the appropriate markband and the specific mark within that band.*

Answers may include:

- **understanding concepts and terminology** of natural income, net productivity, natural capital, stock sustainability, replenishment, maximum sustainable yield, rates of harvest, renewable/non-renewable, goods/services, *etc*
- **breadth in addressing and linking** net productivity and natural income with sustainable harvesting, maximum sustainable yield, impacts of extraction/transport/processing, management of resources, remaining stock/capital, their applicability to abiotic/biotic resources, renewable/non-renewable resources, goods/services, *etc*
- **examples** of net productivity/natural income of named resources *eg* timber, freshwater, fish populations, river processing organic waste, fossil fuels, impacts of unsustainable extraction *eg* bycatch, access roads/infrastructure in forests, *etc*
- **balanced analysis** of the extent to which net productivity and natural income are applicable and sufficient concepts for ensuring sustainable use of a range of resources
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "Both concepts can be very useful in assessing the sustainability of harvesting but net productivity is more limited in its applications since it can only be applied to biotic resources and neither of the concepts take into account any unsustainable damage that may occur through the actual extraction of a resource."

Please see markbands on page 18.

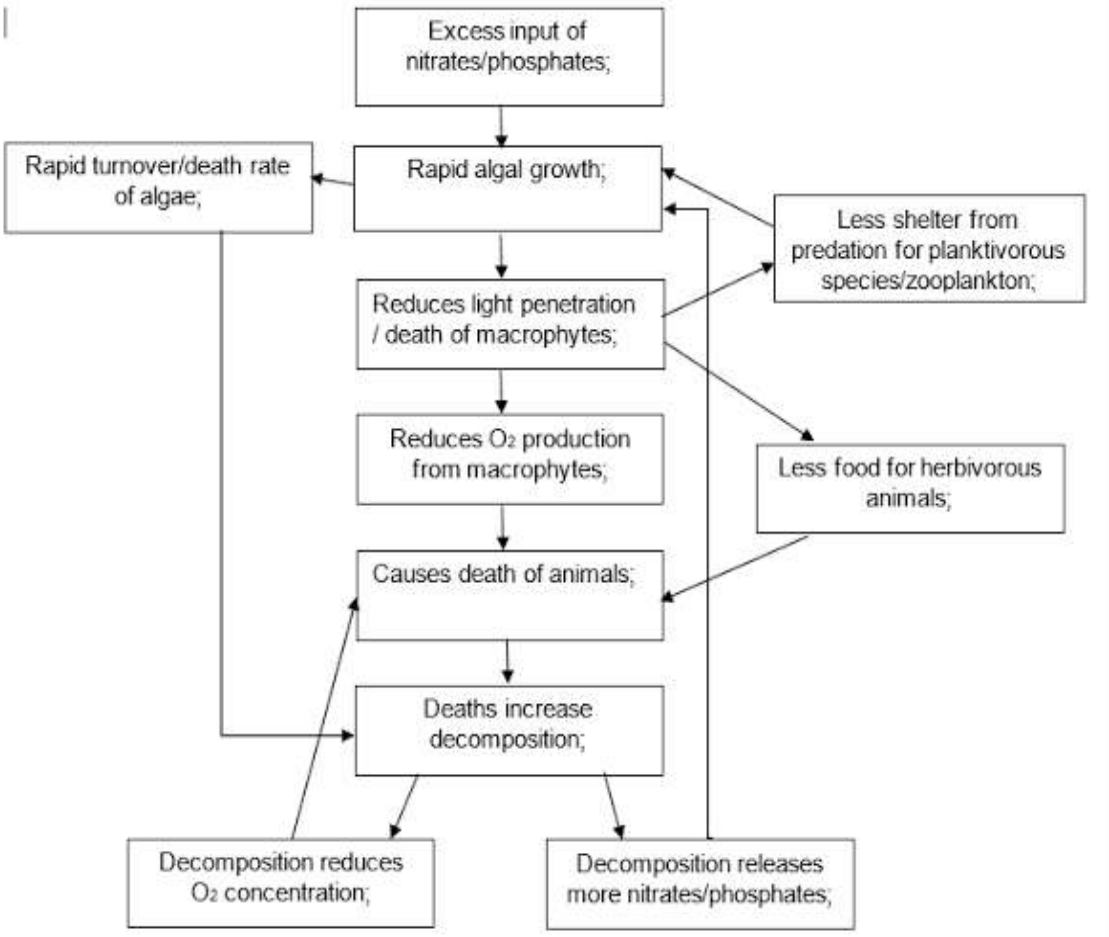
5. (a) Identify **four** characteristics of ecosystems that contribute to their resilience. **[4]**

biodiversity (genetic/species/habitat diversity);
diversity/complexity of interactions/linkages between components/developed food webs/nutrient cycling/establishment of keystone species;
size of storages/population sizes / abundance of resources;
presence of negative feedback mechanisms;
position of tipping points/thresholds of change;
maturity/later stage of succession/climax community;
balance of inputs and outputs / steady state equilibrium;

*Award **[1]** for each correct characteristic identified, up to **[4 max]**.*
Do not accept responses that simply state "storages" or "tipping points", all systems have these. It is the size or position of the storage or tipping point respectively that determines its resilience. Simply stating "biodiversity", however, is acceptable because it is inherently quantitative.
Do not accept responses referring to low human interference, etc. Reduced disturbance may lead to more stable ecosystems, but it does not influence their resilience as such (ie their inherent ability to resist disturbance).

(b) Explain how positive feedback mechanisms may influence the equilibrium of an aquatic ecosystem during the process of eutrophication. **[7]**

in eutrophication, positive feedback amplifies changes in the system and drives it toward a tipping point;
…when a new equilibrium is adopted with low diversity/loss of species/dominance of algae;



*Award **[5 max]** for marking points given above (including each of those in a box on the diagram) or up to **[7 max]** if the processes identified complete a genuine loop of positive feedback ie where a given change promotes further change of same process.*

(c) Pollution management strategies may be aimed at either **preventing** the production of pollutants or **limiting** their release into ecosystems.

With reference to **either** acid deposition **or** eutrophication, evaluate the relative efficiency of these two approaches to management. **[9]**

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Answers may include:

For Eutrophication:

- **understanding concepts and terminology** of eutrophication, distinction between prevention and limiting management strategies, inorganic nutrients, phosphate-free detergents, organic vs inorganic fertilizers, organic farming, domestic and agricultural waste, sewage treatment, N/P stripping, buffer zones, point vs non-point sources, *etc*
- **breadth in addressing and linking** a range of strategies with their effectiveness in reducing impacts of pollutants, from different sources, on different ecosystems, and their relevance and validity for different societies, *etc*
- **examples** of prevention strategies (changing human activity) *eg* alternative fertilisers, P-free detergents, and limiting strategies *eg* N/P stripping phase in water treatment, use of buffer zones, in named case studies/societies, *etc*
- **balanced analysis** of the relative efficiency of the two approaches in reducing impacts on ecosystems; meeting needs of societies, cost and ease of application, *etc*
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* generally, prevention strategies are more efficient because they are directed at the root of the problem, but limiting strategies may be seen as more appropriate from an anthropocentric/technocentric perspective as they will be of less hindrance to productivity

For Acid Deposition:

- **understanding concepts and terminology** of acid deposition, distinction between prevention and limiting management strategies, NO_x and SO_x, atmospheric emissions, fossil fuels, biodiesel, alternative energy, cement/pulp and paper industries, *etc*
- **breadth in addressing and linking** a range of strategies with their effectiveness in reducing impacts of pollutants, from different sources, on different ecosystems, and their relevance & validity for different societies, *etc*
- **examples** of prevention strategies (changing human activity) *eg* using alternative energy sources, *eg* solar, hydro, wind, *etc*, energy saving technology, transport bans/public transport, paper recycling, and limiting strategies *eg* scrubbers, catalytic converters, *etc*
- **balanced analysis** of the relative efficiency of the two approaches in reducing impacts on ecosystems, meeting needs of societies, cost and ease of application, *etc*

- **a conclusion that is consistent with, and supported by analysis and examples given** *eg* “Generally, prevention strategies are more efficient because reducing the use of fossil fuels will simultaneously resolve many other environmental impacts of using this resource which ultimately will become unavailable.”

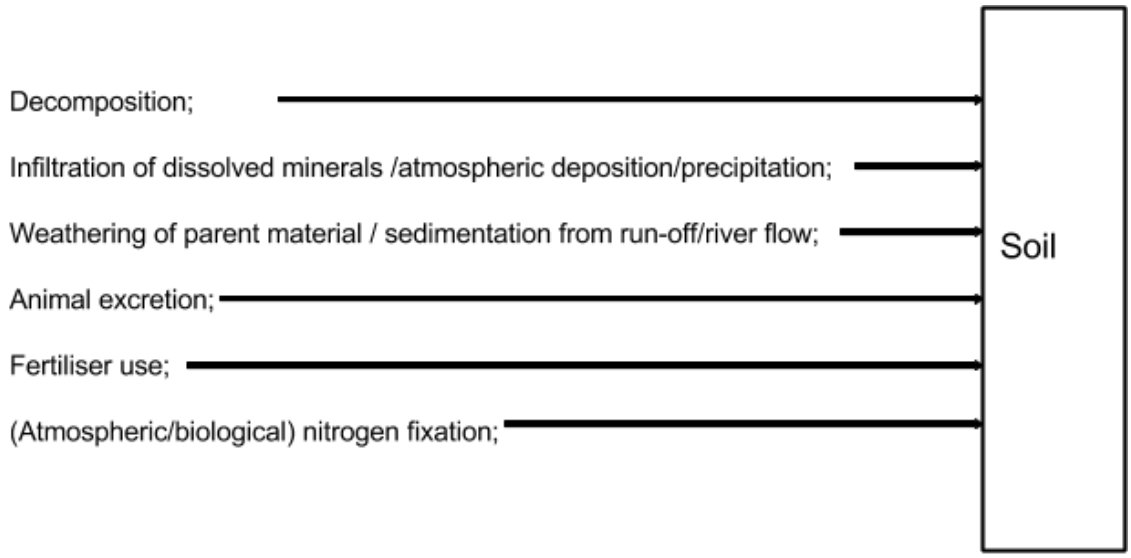
If response addresses both acid rain and eutrophication, only award marks for the higher scoring topic.

Please see markbands on page 18.

6. (a) The soil system includes storages of inorganic nutrients.

(i) Identify **two** inputs to these storages. **[2]**

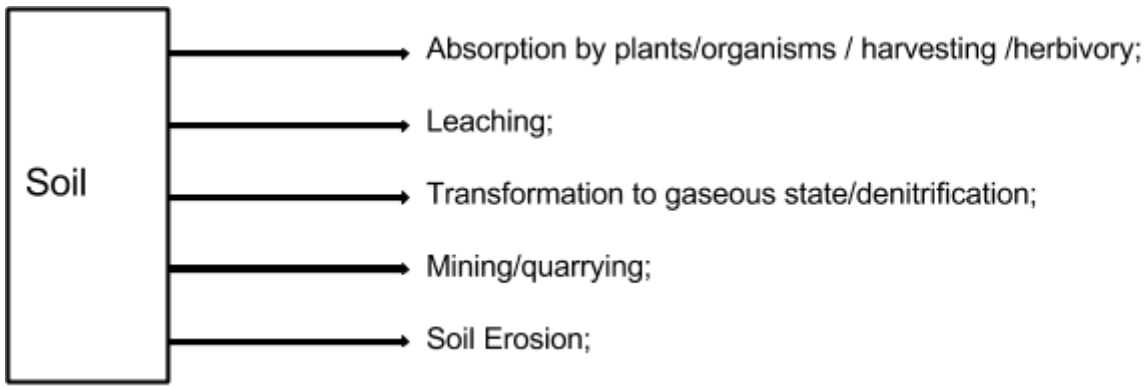
Inputs:



Candidates may present their answers in the form of a diagram, but it is not necessary for full credit.
*Award **[1]** for each correct input identified, up to **[2 max]**.*
Do not credit flows that are transfers or transformations within the soil eg ammonification / nitrification / capillary movement, etc.
Do not accept "pesticides" (these do not provide inorganic nutrients).

(ii) Identify **two** outputs from these storages. **[2]**

Outputs:



Candidates may present their answers in the form of a diagram, but it is not necessary for full credit.
*Award **[1]** for each correct output identified, up to **[2 max]**.*
Do not credit flows that are transfers or transformations within the soil eg ammonification / nitrification / capillary movement, etc.

(b) Solid domestic waste may contain non-biodegradable material and toxins that have the potential to reduce the fertility of soils.

Explain how strategies for the management of this waste may help to preserve soil fertility. **[7]**

recycling/re-use helps by preventing the release of non-biodegradable material/toxins into the soil;
reduction helps by reducing the quantity of non-biodegradable material/toxins produced/manufactured;
promoting selective consumerism to avoid toxic products prevents them being present in domestic waste;
education/laws/fines that promote disposal of hazardous domestic waste in appropriate collecting facility will reduce their impact on soil fertility;
incineration may be helpful in breaking down non-biodegradable substances/organic toxins;
…and the remaining mineral content can be used to enhance soil fertility;
landfills can limit the release of non-biodegradable material/toxins into soil with effective lining;
sorting of waste before entry to landfill can remove many toxic substances *eg* batteries/fluorescent lamps/tyres/spray cans reducing risk to soil fertility through leakage;
deep well injection of hazardous wastes will prevent soil toxification;
all strategies that prevent release of toxins will preserve the soil fauna that contribute to fertility;
composting (although it does not breakdown non-biodegradable material/toxins) can compensate to some extent by providing soil nutrients that improve soil fertility;

*Award **[1]** for each correct explanation, up to **[7 max]**.*

(c) The provision of food resources and assimilation of wastes are two key factors of the environment that determine its carrying capacity for a given species.

To what extent does the human production of food and waste each influence the carrying capacity for human populations? **[9]**

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Answers may include:

- **understanding concepts and terminology** of carrying capacity, ecological footprint, waste assimilation, recycling/re-use/reduction strategies, BOD, toxicity, greenhouse gases, global warming/climate change, selective breeding/genetic engineering, commercial vs artisanal farming, mono-cropping, soil quality, desertification, Malthus/Boserup theories, *etc*
- **breadth in addressing and linking** a range of ways in which different sources of waste *eg* agricultural, domestic, industrial, transport *etc* and food production systems *eg* commercial, polyculture, artisanal, *etc* impact/deplete available resources thus influencing carrying capacity for humans, *etc*
- **examples** of how carrying capacity may be influenced through wastes *eg* toxicity to natural populations, increasing BOD in aquatic systems, greenhouse gases leading to global warming/climate change reducing (or possibly increasing?) productivity, and through food production *eg* use of pesticides reducing natural populations, reducing soil quality through overharvesting/compaction/irrigation, habitat destruction, *etc* and examples of how these influences may be reduced through waste management strategies *eg* recycling, etc, alternative energy, and alternative agricultural practices *eg* polyculture, crop rotation, more efficient crops/GMOs, *etc*
- **balanced analysis** of the net impact of waste and food production on the carrying capacity for humans *etc*
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "Although there are many mitigating strategies that can reduce the influence of waste and food production on carrying capacity, overall, an increasing per capita footprint of humans will inevitably result in a reduced carrying capacity."

Please see markbands on page 18.

7. (a) Identify **four** reasons why the genetic diversity of a population may change over time. **[4]**

mutation may lead to new genotypes/increased diversity;
natural selection/survival of fittest may eliminate some genotypes/reduce diversity;
(human activities) *eg* pollution/hunting/habitat destruction/alien species may reduce population/diversity / lead to a bottleneck effect;
migration causing mixing of populations/subjection to new selective pressures;
climate change may eliminate certain genotypes/reduce diversity;
…or lead to evolution of new genotypes/increase diversity;
(tectonic activity may create) natural barriers leading to divergent evolution/speciation/greater diversity;
genetic drift/random loss of genes;
mixing of GMOs/selectively bred/farmed escapees introduces new genes to wild populations;

Accept any other reasonable suggestions.
Responses that identify relevant factors eg "mutation", but do not identify why/how this influences diversity should not gain full credit.
*Award **[1 max]** for responses that list three valid factors without identifying how they influence diversity.*
*Award **[2 max]** for responses that identify four such factors.*
*Award **[1]** for each correct reason identified, up to **[4 max]**.*

(b) Explain how changes in the concentration of stratospheric and tropospheric ozone in the atmosphere can affect global biodiversity. **[7]**

*Award **[1]** for the following point:*

stratospheric ozone has decreased and (production of) tropospheric ozone has increased;

*Award **[1]** for each part of the explanation given below, up to **[6 max]**.*

change in stratospheric ozone allows more UV radiation to reach earth;
…which causes mutations/damage to DNA/cancers;
…(possibly) resulting in death of organisms/reduction in biodiversity;
…also reduces plant growth/NPP/especially phytoplankton / damages chlorophyll;
…affecting populations all along food chain/reducing diversity of food web; ***[4 max]***

change in tropospheric ozone in urban areas gives rise to photochemical smog;
…that is toxic (to humans/other species);
…damages plant leaves reducing NPP of ecosystems/food chains;
…tropospheric ozone is a greenhouse gas contributing to global warming/climate change;
…resulting in population declines/death/reduction in biodiversity; ***[4 max]***

Do not credit the common misconception that ozone depletion/UV radiation leads to global warming (its connection, if any, is negligible).

(c) Environmental value systems differ in how they view the importance of biodiversity and this could influence their approach to conservation.

Discuss how these different perspectives, including your own, may influence approaches to conservation. **[9]**

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Answers may include:

- **understanding concepts and terminology** of environmental value systems, biodiversity, habitat/species/genetic diversity, ecocentric/anthropocentric/technocentric, bio-rights, intrinsic value, stewardship, conservation areas/national parks, in-situ/ex-situ conservation, species vs habitat approach, ecotourism; gene banks, plantations, in vitro development, *etc*
- **breadth in addressing and linking** differences in the importance attached to biodiversity by different value systems and associated strategies for conservation *eg* ecocentrics will attach particular importance to intrinsic value of biodiversity and the rights of all species, their focus will be on minimising any human intervention, conserving habitat diversity and pristine ecosystems, *in-situ* conservation areas/national parks, technocentrics may attach particular importance to the potential resources that biodiversity provides for human population, they may focus more readily on species more useful to humans and the potential of genes in providing resources, the use of gene banks and technology for in vitro development/ex-situ breeding programmes of "useful" species, anthropocentrics will attach particular importance to the ability of biodiversity in stabilising ecosystems so they can be managed for human benefit, through ecotourism, sustainable harvesting, conservation efforts will depend heavily on social engagement/legislation, *etc*
- **examples** of environmental value systems *eg* deep ecologists, ecocentric, anthropocentric, environmental managers, technocentric, cornucopian, and approaches to conservation *eg* habitat/*in-situ* conservation, *ex-situ* zoos/breeding programmes, ecotourism, gene banks/genetic engineering/in vitro development, flagship species
- **balanced analysis** of how different perspectives on biodiversity adopted in different value systems can influence the emphasis and selection of conservation strategies
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "My own perspective is rather on the borderline of ecocentric and anthropocentric viewpoints because, unlike the more extreme ecocentrics, I do believe humans have a unique responsibility in the natural world. And yet, the anthropocentric view of biodiversity as a pragmatic means to an end lacks some of the mystery and spirituality I associate with nature that is more evident in the ecocentric's perspective."

Please see markbands on page 18.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.