2224 – 6503M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Environmental systems and societies

Standard level

Paper 2

18 pages

Subject details: Environmental systems and societies SLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[25]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[65]**.

1. Environmental systems and societies uses marking points and markbands to determine the achievement of candidates

When using marking points (<u>All of this paper except</u> Section B, part (c) questions):

i. A markscheme often has more marking points than the total allows. This is intentional
ii. Each marking point has a separate line and the end is shown by means of a semi-colon (;)
iii. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **<u>precise point</u>** where it becomes clear that the candidate deserves the mark. **<u>One tick to be shown for each mark awarded</u>**
iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (<u>Only</u> for Section B, part (c) questions):

i. Read the response and determine which band the response fits into
ii. Then re-read the response to determine where the response fits within the band
iii. Annotate the response to indicate your reasoning behind the awarding of the mark
Do not use ticks at this point
iv. Decide on a mark for the response
v. At the end of the response place the required number of ticks to enable RM Assessor to input the correct number of marks for the response.

2. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

3. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

4. Words that are <u>underlined</u> are essential for the mark.

5. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).

6. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

7. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

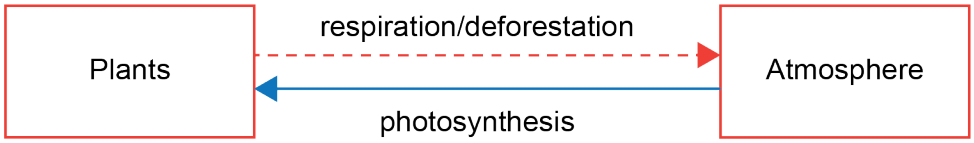
8. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Section A

1. (a) Identify **one** carbon flow caused by human activities in **Figure 1**. **[1]**

Deforestation and land use change / Burning fossil fuels

(b) Draw a labelled diagram to illustrate the flows of carbon between plants and the atmosphere shown in **Figure 1**. **[2]**



flows: respiration/deforestation *AND* photosynthesis;
stores: plants *AND* atmosphere;

***Note:** [1] for correctly labelled stores;*
[1] for correctly labelled flows in each direction;

(c) Using the data in **Figure 1**, calculate the net gain in carbon in the oceans in 10^{15} g. **[1]**

(92 + 0.8) – (90 + 0.1) = 2.7 (x 10^{15} g C yr^{-1})

(d) Describe **one** advantage and **one** disadvantage of the oceans as a carbon sink. **[2]**

Advantage:
oceans are large so absorb a lot of CO_2 / increases primary productivity/photosynthesis / reduces global warming/climate change;

Disadvantage:
increasing CO_2 in oceans causes acidification / ocean acidification harms sensitive marine species/ecosystems like coral reefs;

(e) Outline **one** method to mitigate the effects of atmospheric carbon storage. **[1]**

a. reforestation/afforestation initiatives so that more carbon can be absorbed;
b. carbon capture and storage/CCS to bury CO_2 underground;
c. land use change/urban renewal leading to revegetation/green roofs to absorb CO_2;
d. switch to renewable energy to reduce use of fossil fuels;

***Note:** There are multiple acceptable responses to this question i.e. any process that reduces release of CO_2 or absorbs CO_2 from atmosphere*
NB This is an "outline" question, not "identify", so requires a little more than "reforestation" (i.e. WHY reforestation?) or "reduce use of fossil fuels" (...need to state HOW fossil fuel use might be reduced),

2. (a) Using **Figure 2**, estimate the mass of plastic that was produced in 2017. **[1]**

430 million tonnes;

Note: *accept +/– 10 million tonnes. Units must be included for credit.*

(b) Calculate the percentage of accumulated plastic that was recycled between 1950 and 2017. **[1]**

(700 million tonnes / 9200 million tonnes) = 7.6(%)

(c) Outline why the total accumulated plastic in 2017 is greater than the yearly production. **[1]**

because it does not biodegrade/get incinerated as fast as it is produced / because every year adds to the previous year that still exists/is in use / because the accumulated plastic is over a longer time than one year;

(d) Describe how the environmental impacts of discarded and incinerated plastic waste would differ. **[2]**

a. incinerated plastic may release CO_2/toxic gases/ashes/greenhouse gases;
b. incinerated plastic would be reduced in volume;
c. incinerated plastic may be used to produce electricity reducing need for fossil fuels;
d. discarded plastic will take up space in landfill;
e. discarded plastic may enter oceans/food chains/mistaken for food and ingested/cause physical harm to species;
f. discarded plastic causes visual pollution/beach litter/affects aesthetic value/ property value/tourism;
g. incineration may reduce urgency to recycle/reduce waste;
h. discarded plastic may release methane in sunlight;

Note: *Allow 1 max if response addresses only discarded or only incinerated plastic.*

(e) Describe **two** possible methods to reduce the future trends of plastic production shown in **Figure 2**. **[2]**

a. recycling/reusing plastics so that less needs to be produced;
b. regulations/laws/bans limiting the amount of plastic that can be produced;
c. increasing taxes/prices on plastics to discourage production / consumption;
d. campaigns/education to change human behaviour/plastic consumption;
e. development of biodegradable substitutes (e.g. starch “plastic”) / use alternative packaging;

Note: *Accept other valid and reasoned response*

(f) Explain **two** potential impacts of the future trends of plastic production on the global ecological footprint. **[2]**

ecological footprint will increase because
a. manufacturers are likely to increase carbon emissions/fossil fuel use;
b. waste disposal will occupy land area;
c. resource use will increase;
d. incineration will increase carbon emissions;

ecological footprint may decrease because
e. plastic may replace wood/metal as raw materials thus preserving ecosystems;

Note: *Do not credit responses that make no explicit reference to change in EF*

3. (a) Identify the time of day that ozone is at its lowest concentration on a wet day in **Figure 3(a)**. **[1]**

07:00

Note: *Accept between 06:30 and 07:30*

(b) Outline **two** reasons for the trend of hourly ozone concentrations shown in **Figure 3(a)**. **[2]**

a. sunlight/hydrocarbons/NOx emissions are necessary for ozone formation;
b. sunlight/heat rises in the morning/afternoon, increasing ozone levels / decreases at night without sun;
c. hydrocarbon/NOx emissions from traffic highest at rush-hours in morning and afternoon / lowest at night;

(c) Describe **one** impact of high SO_2 concentrations on forest systems. **[1]**

acid deposition on forests causing tree dieback / leaching of plant nutrients / can kill soil microbes / can release metals that can be toxic to plants/microbes;

Note: *Do not credit "acid deposition" alone or just the impact alone, they must connect acid deposition to the impact.*

(d) Outline **one** possible source of the pollutant shown in **Figure 3(b)**. **[1]**

a. burning of fossil fuels in power plants/industry;
b. combustion of fossil fuels in motor vehicles;
c. manufacturing fertilizers / cement kilns / oil refining;
d. lightning oxidizes atmospheric nitrogen / soil microbial activity / volcanic activity;
e. incineration of waste

(e) Outline why SO_2 levels are lower on wet days than on dry days, as shown in **Figure 3(c)**. **[1]**

SO_2 dissolves in water / is removed from the atmosphere when it rains/forms acid rain;

(f) Evaluate a strategy to manage the effects of **one** pollutant named in **Figure 3(b)** or **Figure 3(c)**. **[3]**

Example NOx/SO_2: replacing use of fossil fuels with alternative energy sources;
Advantage: it eliminates emission of pollutants altogether;
Disadvantage: it would involve major social changes that may be unpopular;
Appraisal: could be successful in a society that has strong ecocentric principles;

Example NOx: use of catalytic converters to trap emissions;
Advantage: would enable continued use of fossil fuels appropriate to popular technology;
Disadvantage: allows continued emission of other pollutants e.g. CO_2/hydrocarbons;
Appraisal: would be relatively easy to introduce and enforce in a society;

Example NOx/SO_2: clean-up of acidified aquatic ecosystems using lime;
Advantage: relatively easy to apply / no requirement for popular cooperation;
Disadvantage: expensive and short term solution;
Appraisal: in the long run it would be better to remove root cause

Note: *Allow 1 max for each valid e.g./advantage/disadvantage/appraisal up to 3 max. Accept other valid strategies.*

Section B

4. (a) Outline the distinctive features of the anthropocentric environmental value system. **[4]**

It ascribes to:

a. a human responsibility to maintain the environment;
b. concept of stewardship;
c. sustainable exploitation of the environment;
d. management/supervision of human activity;
e. imposing sustainable practices through legislation;
f. use of incentives/disincentives to regulate exploitation (compensations/taxes/fines etc.);
g. public debate to reach consensual resolutions/pragmatic approaches;
h. population control is of equal importance to management of resource use;

Note: *Allow credit for any feature that distinguishes anthropocentrism form one or more alternative value systems.*
Do not credit responses implying more cornucopian values e.g. Human supremacy / dominance over environment / only concerned with human benefit.

(b) With reference to a named herbivore species, explain why its population growth curve follows an S-shape. **[7]**

a. original colonisers are small in number;
b. unfamiliarity with local resources/habitat may hinder early growth/result in a lag phase;
c. as they reproduce there are more individuals that can reproduce/few limiting factors to constrain growth;
d. this creates a faster growth rate;
e. resulting in positive feedback/exponential increase;
f. growth rate/curve eventually slows down/flattens/plateaus out due to limiting factors;
g. limiting factors may include e.g. food/water/nesting material etc.;
h. if population increases this will reduce food availability/increase predation;
i. causing a subsequent decrease in population/minor fluctuations in growth rate;
j. maintaining a stability/equilibrium/carrying capacity/negative feedback/density dependent regulation

Note: *accept marking points on an annotated diagram*
Award 6 max if no herbivore is named.

(c) To what extent would an anthropocentric approach to addressing human population growth be the most successful in maintaining a sustainable population? **[9]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria 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 demonstrate:

- **understanding concepts & terminology** of anthropocentrism; ecocentrism; technocentrism; soft ecologists; environmental managers; carrying capacity; ecological footprint; population policies; pro-natal/anti-natal; incentives; disincentives; sustainable development; personal and communal improvement; community involvement; legal regulations; etc.
- **breadth in addressing and linking** different value systems and different approaches to population regulation including a range of development policies.
- **examples** of anthropocentric national/international policies, other named value systems; national populations and population policies etc.
- **balanced analysis evaluating** extent to which anthropocentric policies are most conducive to sustainable development of human populations compared with other approaches.
- **a conclusion that is consistent with, and supported by analysis and examples given** e.g. Anthropocentric approaches to maintaining a sustainable population are more realistic than the ideology of ecocentric approaches and the recklessness of extreme technocentric approaches.

NB Although our syllabus takes the view of anthropocentrism indicated in MS for 4a, there is a popular perception that is more toward a cornucopian value system, where humans are rightfully dominant over the environment and nature has a purely instrumental value as it serves humankind. While this represents a misunderstanding of the term defined in our syllabus, please apply the spirit of ECF and be prepared to credit arguments based on this perception.

Please see markbands on page 18

5. (a) Outline the processes by which nitrogen in the atmosphere may eventually be found in the protein of a decomposer. **[4]**

a. nitrogen cycles within ecosystems/is recycled in the Earth system;
b. nitrogen gas may diffuse into the soil;
c. nitrifying bacteria convert the nitrogen to ammonium/nitrites;
d. further bacteria convert the nitrites to nitrates;
e. lightning transforms/oxidises the nitrogen to nitrates;
f. nitrates are taken up by the roots of plants;
g. nitrates are transferred to the leaves of plants;
h. nitrates are assimilated into organic molecules/amino acids/proteins/nucleic acids in the plant;
i. the leaf/plant dies and enters the soil/becomes detritus;
j. the proteins are consumed/absorbed by decomposers/detritivores/saprotrophs;

Note: *Marking points may be credited if conveyed explicitly by an appropriate annotated diagram.*

(b) Explain why pyramids of numbers, biomass and productivity may vary in shape for different food chains**.** **[7]**

a. pyramids of productivity tend to get smaller at higher levels;
b. this is because energy is lost between trophic levels;
c. seasonal productivity at lower levels could temporarily be smaller;
d. …but annual productivity should always decrease at higher levels;
e. pyramids of numbers tend to get smaller at higher levels due to losses;
f. …but may get larger if individuals at lower trophic levels are larger (e.g. trees);
g. pyramids of biomass tend to get smaller at higher levels due to losses;
h. …but as they reflect standing stock (and not rate of flow) they can be inverted;
i. pyramids may become larger at higher levels if they represent a single food chain in a larger food web;
j. …because more biomass may be fed in from other food chains;
k. food chain with more trophic levels will have longer shape;
l. pyramids of productivity tend to be pyramid shaped because they show flow of energy over time;
m. ...and because the second law of thermodynamics means energy is lost in the flow;

Note: *Alternative valid points describing/explaining why pyramid shape may vary can be credited.*
Do not credit vague statements claiming shape will be "different" without explaining in what way it will differ.

(c) To what extent can the practical strategies for obtaining data for a pyramid of numbers be made reliable? **[9]**

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Answers may demonstrate:

- **understanding concepts & terminology** of reliability in sampling; quadrats (including number, size, positioning, species distribution); transects; aerial photographs; traps; nets; Lincoln index; mark/release/recapture (including issues of marking technique, trap-happy and trap shy phenomena, time interval); aquatic sampling use of dragnets, kick samples); camera traps (difficulty of extrapolation); general sampling issues (including repetition; extrapolation; seasonal variation; randomisation); total census; abundance; bias; scientific expertise; etc.
- **breadth in addressing and linking** different sampling methodologies with varying degree of reliability for a range of different sessile and motile populations in a range of different habitats;
- **examples** of named sampling methods appropriate for different named species etc.
- **balanced analysis evaluating** extent to which sampling method can be executed to produce reliable data; practical issues hindering application of methodologies in the field.
- **a conclusion that is consistent with, and supported by analysis and examples given** e.g. All methods of sampling inevitably involve a degree of inaccuracy compared with a total census, but they can always be made more reliable by repeated executions.

Please see markbands on page 18

6. (a) Outline the mechanisms by which a terrestrial species may have evolved from an aquatic ancestor. **[4]**

a. there was genetic variety in aquatic species / mutations accumulated over years;
b. certain features may have adaptation/advantage for terrestrial existence;
c. individuals with these features could colonize terrestrial habitat;
d. they would be more likely to survive/survival of the fittest/experience less competition (natural selection);
e. they produce offspring like themselves/feature will become more abundant;
f. individuals with feature may be unable to breed with others without feature /speciation occurs / reproductive/geographical barrier will give rise to new terrestrial species;

(b) Explain the ways in which species diversity and an abundance of plant and herbivore species will increase the resilience of an ecosystem. **[7]**

Diversity:
a. a greater diversity of plant and herbivore species would mean there are more species to take over the role of any that would be lost/creates a more complex food web;
b. a wider variety/diversity set of plant species will support a wider range of herbivores/increase habitat diversity;
c. a wider variety/diversity of plant species will be able to exploit a wider range of abiotic conditions;
d. more plant species/greater plant diversity will be more likely to include species that will survive a change in conditions;
e. a wider variety/diversity plant species will increase interspecific competition resulting in evolution of more species;
f. a wider variety/diversity of herbivorous species will support a wider range of predators;
g. a wider variety/diversity of herbivore species will occupy a wider range of niches adding to the complexity of the system;

Abundance:
h. a greater abundance/larger populations of plant species means greater primary productivity which supports a greater abundance/larger populations of herbivores;
i. a greater abundance/larger populations of plant species is less likely to become extinct from the ecosystem;
j. a greater abundance/larger populations of herbivores will support a greater abundance/larger populations of predators;
k. a greater abundance/larger populations of herbivores will be less likely to become extinct in the ecosystem;

(c) Evaluate management strategies for reducing the impact of agricultural pollution on an aquatic ecosystem. **[9]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria 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 demonstrate:

- **understanding concepts & terminology** of agricultural pollution; inorganic fertilizers; organic run-off/slurry; persistent pesticides; biomagnification; erosion; spraying; biological control; buffer zones; organic fertilizers; eutrophication; mud-pumping; re-introduction of aquatic species; levels of pollution management etc.
- **breadth in addressing and linking** different forms of agricultural pollutants with effective management strategies to protect or clean-up different aquatic ecosystems.
- **examples** of different pollutants; agricultural practices; management strategies; aquatic systems etc.
- **balanced analysis evaluating** advantages and disadvantages of management strategies employed to reduce impacts of agricultural pollution.
- **a conclusion that is consistent with, and supported by analysis and examples given** e.g. The most effective management strategies are those that prevent pollutants being released in the first place e.g. replacing inorganic with organic fertilizers, but this is not always the most economically feasible for farmers.

Please see markbands on page 18

7. (a) Outline **two** input processes and **two** output processes that occur to and from the soil system. **[4]**

Inputs; ***[2 max]***

a. water is added through precipitation/infiltration;
b. humus/detritus/organic molecules are added through leaf fall/death of organisms;
c. minerals are added when they dissolve in precipitation/percolating water;
d. minerals are added through weathering of parent rock;
e. usable nitrogen/nitrates/ammonia is added through nitrogen fixation/nitrification;

Outputs: ***[2 max]***

f. water is lost through evaporation/plant uptake;
g. minerals are lost through leaching;
h. soil/minerals/nutrients lost through wind/water erosion;
i. minerals are taken up/absorbed by plants;
j. nitrates are converted/lost to nitrogen gas (by bacteria) through denitrification;

(b) Explain how negative and positive feedback mechanisms play a role in the process of global warming. **[7]**

*Allow **[1 max]** for general description of negative and positive feedback either as a separate knowledge statement or explicitly in e.g.:*
negative feedback occurs when increase in global warming promotes reduction/stabilization of global warming and positive feedback occurs when it promotes further increase in global warming;

*Allow **[2max]** per loop given below.*

Negative feedback loops;
(Increased temperatures…)
a.…leads to increased evaporation…;
b. …which leads to increased cloud cover…;
c.…which leads to greater albedo…;
(…which decreases global temperature)

(Increase in global temperatures/CO_2 concentrations…)
d.…leads to increased rates of photosynthesis…;
e.…which is assimilating more CO_2…;
f.…which is a greenhouse gas/ thus less outgoing heat/emitted long-wave radiation is absorbed…;
(…leading to lower global temperatures/CO_2 concentrations)

Positive feedback loops:
(Increased global temperatures…)
g.… lead to increased evaporation...;
h.…which leads to more water vapour…;
i.…which is a greenhouse gas/absorbs outgoing heat/emitted long-wave radiation...;
(which increases global temperature);

(Increased global temperatures…)
j.…leads to melting of permafrost/glaciers…;
k.…leading to increased methane release…;
l.…which is a greenhouse gas / absorbs outgoing heat/emitted long-wave radiation…;
(…which increases global temperature)

(Increased global temperatures…)
m.…leads to melting of polar ice caps…;
n.… leading to reduced ice/albedo;
o.…which leads to less reflection of incoming solar radiation…;
(which increases global temperature);

***Note:** Allow **[4max]** if only positive or only negative feedback is addressed.*
Allow credit for any other valid feedback loops relating to ocean expansion/forest fires/desertification etc.
Credit appropriately annotated drawings.

(c) To what extent are the concepts of natural capital and natural income helpful in managing the sustainable use of natural resources? **[9]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria 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 demonstrate:

- **understanding concepts & terminology** of natural capital; natural income; resources; goods; services; sustainability; maximum sustainable yield; optimal sustainable yield; overexploitation; quotas; ecological footprint; Millenium ecosystem assessment; renewability; various values of natural capital/income (aesthetic, cultural, biological, ecosystem services); etc.
- **breadth in addressing and linking** different forms of natural capital and the income they generate with different appropriate management strategies to regulate harvesting, extraction, transport, processing; etc.
- **examples** of named natural capital, of how the goods and services they provide are valued, natural income and named sustainable management strategies etc.
- **balanced analysis evaluating** extent to which these concepts of natural capital and income provide a useful model around which management can be conceived and executed.
- **a conclusion that is consistent with, and supported by analysis and examples given** e.g. These concepts are particularly useful because they emphasize the value or preserving the ability to produce future income from the resources although it is not always easy to translate these concepts into actual data that would represent sustainable quotas.

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.