2226 – 4630M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Environmental systems and societies

Higher level

Paper 2

18 pages

Subject details: Environmental systems and societies HLP2 Markscheme

Mark allocation

Candidates are required to answer:

- **ALL** questions in Section A **[40]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[80]**.

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

When using marking points (All of this paper except 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 **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded**
iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (Only 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 underlined 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 forwar(d) 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) Complete the table to identify the population pyramids with ~~to~~ the correct stage of the DTM **[2]**

Stage of the DTM	Population pyramid
1	D
2	C
3	A
4	E
5	B

Note to examiner: *Award 1 mark for 2 correct responses and the second mark for ALL 5 correct responses*

(b) Calculate the Doubling time for Nigeria **[1]**

Nigeria DT
70/2.124 = 32.96 <u>years;</u>

Accept range 32.9-33 <u>years</u>

(c) Describe the impacts of Nigeria’s doubling time on its population and environment **[3]**

a. A low DT will cause a high population growth rate/overpopulation;
b. Maybe exceed biocapacity/carrying capacity/increase ecological footprint;
c. Increased demand for food…;
d. ...Which will cause destruction of natural environment/deforestation/depletion of natural capital;
e. Increased demand for water for agriculture, industry and domestic;
f. Higher demand for energy which will…;
g. Possibly cause an increase in carbon emissions / climate change issues;
h. Pressure on health care services-spread of disease/epidemics;
i. Increased mortality rate;
j. Increased production of waste / pollution;
k. Excessive demand for natural resources/housing/building materials;
l. Low per capita income /unemployment / underemployment;
m. Low quality of life/happiness index;
n. Loss of biodiversity;

(d) Suggest how Afghanistan could reduce its crude birth rate. **[2]**

a. Provide education for women (about family planning);
b. Raise awareness and availability of contraception;
c. Provide family planning centres;
d. Support micro-lending;
e. Reduce infant and childhood mortality rates;
f. Provide old-age security in the form of pensions;
g. Improve the status of women – female emancipation / equality/access to jobs/education;
h. Address inheritance laws;
i. Introduce anti-natalist policies (e.g. one-child policy);

Note to examiner: *Accept other valid points*

(e) Explain the role population momentum plays in population growth **[3]**

a. Population momentum explains why the population continues to grow even when the total fertility rate falls;
b. This is linked to population structure and the percentage of the population in the reproductive age group;
c. Any population that has a high proportion of young people will have a higher population growth;
d. The fertility rate may still be at replacement level but…;
e. …The sheer number of women who can have children will cause forward "momentum"/ high CBR / population growth/birth rate exceeds death rate;

2. (a) Mountain view has a species diversity of 2.48. Using the Simpsons reciprocal index calculate the index for Barlow Field. **[2]**

$D = \frac{N(N-1)}{\Sigma\, n(n-1)}$

Where
N is the total number of individuals in the population
n is the number of individuals of a single species.

Barlow Field has a Simpson diversity index of 1.73 / 1.726

$$D = \frac{136(135)}{10(9)+26(25)+100(99)} = \frac{18360}{90+650+9900} = \frac{18360}{10640}$$

$D = 1.73$

(accept range 1.7-1.73 e.g. 1.726 is accepted)

Note to examiner: *1 mark for correct layout of the data in the formula.*
The second mark is to be awarded is the answer if given as 1.73 or within the range above 1.7-1.73

(b) (i) Distinguish between species richness and species evenness. **[1]**

Species richness is the number of species in a specific community whereas evenness is how similar/comparable/balanced the population sizes of each species are;

(ii) Explain why species richness and species evenness are significant when considering biodiversity. **[3]**

Richness:
a. Species are dependent on each other directly or indirectly so high species richness means the loss of one species has less of an impact;
b. Allows for more diverse/highly branched food webs and resilience/recover faster from diseases/environmental disturbances;
c. Many niches are filled, reducing opportunities for invasive species;
d. A wide variety of species allows a healthy/productive ecosystem to provide essential life support systems for all life on earth;

Evenness
e. If the populations of different species are even, then this ensures that no single species dominates = more stable and resilient ecosystem;
f. For example, if aspen and willow populations are similar in Yellowstone or zebra and wildebeest populations are similar in size in the Serengeti (accept other examples);
g. An even distribution of species’ numbers means there will be complementarity between the species;
h. Interspecific competition can be greater leading to greater fitness;

Both
i. Contributes to a higher biodiversity index/biodiversity/genetic diversity (credit if this is mentioned in relation to either term or both, 1 max.);

(c) Speciation is the process by which new species form. Explain using examples the mechanism by which speciation may occur. **[3]**

Type of isolation	Explanation
Geographic	Populations of a species are <u>physically</u> separated/isolated to prevent exchange of genetic material; (e.g. a large highway/river/lakes/continental drift/plate tectonics/islands separates groups of the same species)
Temporal	Some members of a species may find a competitive advantage that isolates them from reproducing/exchanging genetic material with the original population/biological clocks of groups are out of alignment and they are ready to reproduce at a different time; e.g. changing the time of day, they are active (day vs night) e.g. changes in reproductive season e.g. long and short-day plants will not mix/hybridise due to different times/seasons of flowering
Behavioural	Behavioural changes reproductively isolate one population from another; e.g. courtship displays become unsynchronised/a male might have a unique song/dance/colouration that attracts only some females. Over time this is continued for generations leading to speciation and a distinct species with its own song.

Note to examiner*: 1 mark per type of isolation. Both an explanation and an example are needed for the award of the mark. Accept examples that are valid and used to present explanations of the concept. The example can be used to show the concept.*
Award 1 max for no examples and ALL correct explanations.

(d) Using a named species, define what is meant by an endemic species. **[1]**

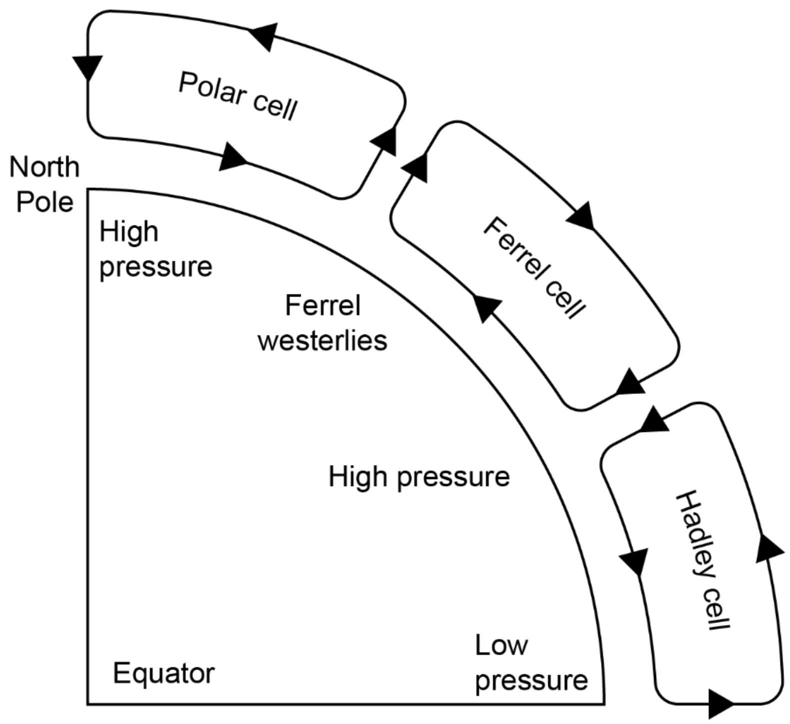
Endemic means native to a specific geographical region;
e.g. Darwin's finches (e.g. green warbler finch (*Certhidea olivacea*), Grey warbler finch (*Certhidea fusca*), mangrove finch (*Geospiza heliobates*) are a species of bird that is only found on one of the Galapagos islands and nowhere else on earth.

Note to examiner: *Accept other valid examples including extinct species like the dodo (Raphus cucullatus) endemic to Mauritius. The definition can be linked to the example, but <u>BOTH</u> are required for 1 mark.*

(e) Explain why high rates of endemism occur on isolated islands. **[3]**

a. These immigrant species may have less competition;
b. Plenty of new ecological niches to occupy/ some mutations lead to adaptive radiation;
c. Genetic diversity of individual population tends to be low/founder effect…
d. …But species diversity within the community could be high;
e. Population size may be limited/genetic drift;
f. There is limited interchange/interaction with neighbouring mainland or island biota;
g. New incoming organisms may not be able to breed with the endemic species…;
h. ...so, there is no new introduction of genetic material/reproductive isolation;
i. The endemic species on islands are isolated and can't escape to other places;

3. (a) Annotate diagram to show direction of air movement **[2]**



Note to examiner: *Annotate 3 cells correctly for 2 marks, only the arrow directions are required for award of marks.*
Award ***1 if ANY TWO*** *CELLS are correctly annotated.*

(b) Explain how the tri-cellular model accounts for the rainfall patterns of the tropical rainforest and the desert around the globe **[3]**

a. The sun is high in the sky/directly overhead at the ITCZ where the tropical rainforests are located - this heats the ground, and the warm air rises in convection currents…;
b. …rising air cools and condensation causes the formation of (cumulonimbus) clouds;
c. …when saturation point has been met heavy rainfall will occur;
d. At high altitudes, the air moves pole-wards and at 30°N and 30°S (over the deserts) the colder air begins to sink back towards earth’s surface…;
e. …as the air descends it creates a high-pressure zone / residual moisture evaporates;
f. …the air expands / is dry, hence lack of rainfall in desert regions;

4. (a) Using **Figure 4** draw a food chain with 4 trophic levels **[2]**

a. Gum tree-> termite -> echidna-> dingo;
b. Wattle tree –> termite -> echidna-> dingo;
c. Grasses –> termite -> echidna-> dingo;
d. Grasses –> crickets –> frilled lizard –> dingo;
e. Grasses –> crickets –> frilled lizard –> wedge-tailed eagle;
f. Grasses –> crickets –> frilled lizard –> laughing kookaburra;
g. Grasses -> crickets -> wombat-> dingo;

Note to examiners*: 1 mark for ALL organisms in correct sequence, 1 mark for correct arrow direction.*

(b) State one impact of the removal of the echidna from this food web. **[1]**

a. Population of termites may increase (due to the reduced predation by the echidna);
b. Magpie population would increase (due to less competition for termites);
c. Population of emu/wombat/ frilled lizard may reduce (due to increased predation by the dingo);
d. Wattle tree/gum tree/grass population may reduce (due to great herbivory by increased number of termites);
e. Dingo population falls (less prey/food)/emu population falls (less prey options for the dingo);

(c) Explain how the second law of thermodynamics applies to food chains. **[2]**

a. second law of thermodynamics states that the entropy/disorder of a system increases spontaneously/over time / conversions/transformations in energy aren’t 100 % efficient;
b. available energy is lost (to environment) between trophic levels...;
c. ...as heat from <u>cellular respiration/metabolism</u>;
d. often only 10 % of available energy is passed on / 90 % lost between trophic levels / ecological efficiency is limited/limits food chain length;
e. not all parts of the organism are consumed/absorbed/remainder passed to decomposers/stored;

5. (a) State one storage and one flow that are not labelled on **Figure 5** **[1]**

Storage	a. Atmosphere/clouds; b. Ocean; c. Surface storage/lake/pond/groundwater/aquifer; d. Lithosphere/rocks/soil;
Flow	e. Infiltration/percolation; f. Precipitation/rainfall/condensation; g. Throughflow/stream flow/river flow/lake flow; h. Overland flow/run off; i. Transpiration/evapotranspiration; j. Advection/wind; k. Insolation/solar radiation;

Note to examiner: *one storage and one flow are required for 1 mark.*

(b) State two sources of energy that drive the hydrological cycle **[1]**

a. Solar/thermal;
b. Kinetic/wind;
c. Gravity;

Note to examiner: *no credit for ONE source*

(c) Water has unique physical and chemical properties that support and sustain life. Explain how specific heat capacity is important to life. **[2]**

a. The hydrogen bonds in water take a lot of energy to break, this means water takes a long time to heat up or cool down OWTTE…;
b. …this slow rate of temp change keeps the body temperature of warm-blooded organisms relatively constant/maintains homeostasis;
c. …these slow changes are important for the effective functioning of enzymes/metabolic processes;
d. Resists climate change by reducing temperature fluctuations in atmosphere/oceans;
e. Provides stable environment for life;

(d) Explain why the phenomenon in **Figure 6** leads to an increase in the rates of productivity in coastal waters. **[2]**

a. It fertilizes surface water with nutrients from the deeper water…;
b. this encourages phytoplankton and seaweed growth and therefore productivity;
c. high levels (populations) of primary producers encourage fish and invertebrate larva into the area so secondary productivity increases;
d. a more complex food web raises productivity;

Note to examiner: *No credit if productivity increase is linked to sunlight/photosynthesis without a connection to nutrient enrichment.*

Section B

6. (a) Identify four processes included in the planetary boundaries model for sustainability. **[4]**

a. Climate change;
b. Biosphere integrity/management;
c. Land-system change/land use;
d. (Fresh)water use/water resource management;
e. Biogeochemical flows;
f. Ocean acidification;
g. Atmospheric aerosol/particulate loading;
h. (Stratospheric) ozone depletion;
i. Novel entities;

***Note to examiner**: The terms used in the model are required as these are explicitly stated in the ESS Guide (2026).*

(b) Evaluate the role of rare earth elements in the production of renewable energy. **[7]**

Advantages:

a. They are ideal as magnets in electric motors/wind energy turbines;
b. They increase the efficiency/stability of photovoltaic/solar cells;
c. They are used in batteries/fuel cells for the storage of renewable energy/to power EVs;
d. Their role in storage is critical with intermittent energy supplies e.g. wind/solar;
e. They can be recycled;

Disadvantages:

f. They are non-renewable;
g. Their mining creates environmental damage/habitat degradation;
h. Their mining and processing depletes water resources;
i. Their processing releases toxins/pollution;
j. Global distribution is uneven, leading to geopolitical conflicts (e.g. one country holding a monopoly)/risks/unethical practices (e.g. child labour);
k. Their rarity makes them costly;

l. Conclusion [1 max]:

e.g. rare earth elements make renewable energy accessible despite their environmental impacts OR A focus on responsible extraction and long-term recycling will minimise disadvantages and support greater sustainability.

Note to examiner: *Award max 5 if only disadvantages or advantages given. Conclusion not essential for full marks.*

(c) To what extent can economic strategies and models be useful in increasing the sustainability of human communities? **[9]**

Answers may demonstrate:

- **understanding concepts & terminology** of economic models; social/economic/environmental sustainability; planet boundary model; doughnut model; ecological ceiling; social foundation; sustainable development goals; regenerative/distributive economy; circular economy; butterfly diagram; eliminating waste/pollution; circulating materials; regenerating nature; polluter pays principle; greenwashing; tragedy of the commons; Ostrom's shared pastures model; environmental accounting; eco-economic decoupling; zero growth; etc.
- **breadth in addressing and linking** range of economic models/strategies with different aspects of sustainability.
- **examples** of economic models/strategies and the sustainable development goals they address etc.
- **balanced analysis evaluating** both uses and limitations **of** economic models/strategies in addressing sustainability of human communities.
- **a conclusion that is consistent with and supported by analysis and examples given** e.g. While there is an abundance of pertinent models for addressing SDGs, a great deal of work is still required to effectively apply their principles such that genuine sustainability is achieved in human communities.

Please see markbands on page 18.

7. (a) Outline two transfers and two transformations that occur as part of the nitrogen cycle. **[4]**

Transfers [2 max]:

a. Uptake of nitrates/nitrites by plants;
b. Consumption of producers by consumers;
c. Leaching of nitrates through soil/run-off into waterways;
d. Diffusion of atmospheric nitrogen into soil;
e. Human (anthropogenic) application of fertilizers;

Transformations [2 max]:

a. Nitrogen fixation to form NH_4^+ ions/Nitrogen gas to ammonia;
b. Ammonification of dead organic matter;
c. Nitrification of ammonia/ammonium to nitrites*;
d. Nitrification of nitrites to nitrates*;
e. Denitrification to release gaseous nitrogen;
f. Production of nitrous oxide (N_2O);
g. Release of metabolic waste e.g. urea, uric acid, ammonia;
h. Anthropogenic manufacture of ammonia/Haber Process;
** If candidates list ammonia to nitrates award 1 mark but exclude MPs c and d.*

***Note to examiner:** allow credit for annotated and labelled diagrams with transfers and transformations clearly distinguished.*

(b) Explain how data can be collected and manipulated to produce a kite diagram of distribution for a plant species along an environmental gradient. **[7]**

a. Lay out a transect along a gradient;
b. Identify sampling points at regular intervals along a transect;
c. Places quadrats at the selected sampling points;
d. Assess frequency/percentage frequency/cover of plant in each quadrat;
e. Repeat with parallel transects and sampling points;
f. Calculate mean frequencies for each sampling point;
g. Construct horizontal axis representing the transect (samples with intervals);
h. Plot frequency/percentage frequency/cover at each sampling point;
i. Plot this frequency both above and below the horizontal axis;
j. Join the plotted points to form two lines, one above and one below the axis;
k. Shade in the area between the two lines;

***Note to examiner:** credit can be given for an **annotated** kite diagram which includes the MPs above*

(c) To what extent are terrestrial agricultural strategies effective in increasing ecosystem productivity to generate a sustainable food supply. **[9]**

Answers may demonstrate:

- **understanding concepts & terminology** of primary and secondary productivity; arable/pastoral/livestock systems; monoculture v polyculture; irrigated v rain-fed; commercial v subsistence; intensive v extensive; hydroponic v soil based; organic v inorganic; sedentary v nomadic; slash and burn; pesticides; synthetic fertilisers; fallowing; organic fertilisers; mycorrhizae; agroforestry; terracing; contour ploughing; cover crops; windbreaks; soil conditioners; crop rotation; reduced tillage; genetic modification; soil regeneration; rewilding; permaculture; vertical farming; etc.
- **breadth in addressing and linking** range of agricultural strategies with productivity and sustainability of food supply.
- **examples** of named agricultural strategies and their impacts on productivity/sustainability.
- **balanced analysis evaluating** strengths and weaknesses of agricultural strategies in improving productivity and sustainability of food supply systems.
- **a conclusion that is consistent with and supported by analysis and examples given** e.g. since the Green Revolution many agricultural strategies have been very successful in increasing productivity but frequently these have led to a reduction in sustainability.

Please see markbands on page 18.

8. (a) Identify four ways to reduce the environmental impact caused by rural-urban migration. **[4]**

a. Effective/integrated (public) transport systems/strategies to limit vehicle use e.g. HOV and bike lanes;
b. Green spaces / wildlife habitats / allotments;
c. Living green walls/roof gardens/energy efficient architecture/green city planning;
d. Recycling facilities;
e. Rainwater catchment/sponge cities;
f. Vertical/indoor farming/ controlled environment agriculture (CEA);
g. Renewable energy production/electric vehicles;
h. Education/laws (e.g. EIA) /economic instruments (e.g. tax incentives for EVs) to ensure sustainable use of land/resources;
i. Effective waste/pollution management;
j. Zoning/green belt to limit urban sprawl/effective city planning;

Note to examiner: *The focus here is on reduction; do not accept strategies to prevent migration.*

(b) Explain the causes and impacts of photochemical smog. **[7]**

Causes (5 max)

a. Combustion of fossil fuels/use of paints and organic solvents releases primary pollutants;
b. Primary pollutants include NOx / volatile organic compounds (VOCs);
c. Sunlight/insolation converts these primary pollutants to secondary pollutants;
d. Secondary pollutants include peroxyacetyl nitrates (PANs) / tropospheric ozone;
e. These processes may be exacerbated by low wind / temperature inversions;
f. …so are more common in locations surrounded by mountains/high buildings;

Impacts(5 max)

g. Pollutants damage plant cuticles/membranes/limit plant growth/limit light and productivity;
h. Reduces air quality affecting outdoor activities/tourism/the economy/quality of life;
i. Causes eye irritations in humans/mammals;
j. Causes respiratory illnesses in humans/mammals;
k. These health issues will impact healthcare systems/workforce;
l. Also damage some fabric/rubber materials;
m. Reduces visibility leading to traffic delays and hazards;
n. Loss of biodiversity/sensitive indicator species (e.g. lichen)/endanger sensitive species (e.g. frogs);

Note to examiner: *Credit can be given for appropriate annotated diagram addressing any of the marking points above.*

(c) To what extent have international agreements helped to maintain the steady state of the atmospheric system. **[9]**

Answers may demonstrate:

- **understanding concepts & terminology** of steady state; global warming; climate change; ozone depletion; acid rain; photochemical smog; negotiations; protocols; treaties; UN Development Plan; UN Framework Convention on Climate Change; Intergovernmental Panel on Climate Change; COP summits; Montreal Protocol; Kigali Amendment; Kyoto Protocol; Paris Agreement; cross-border carbon taxes; impact of lobbying from stakeholders; environmental constitutionalism; ASEAN agreement on Transboundary Haze Pollution; international environmental law; International and European Courts of Justice; etc.
- **breadth in addressing and linking** range of international agreements with a variety of anthropogenic atmospheric disturbances.
- **examples** of named international agreements and their effectiveness in addressing the steady state of the atmosphere.
- **balanced analysis evaluating** both strengths and limitations of international agreements in addressing issues of atmospheric pollution.
- **a conclusion that is consistent with, and supported by analysis and examples given** e.g. The United Nations have had a number of successful outcomes in addressing global atmospheric instabilities, but management of the more localised impacts of acid rain and photochemical smog tend to naturally to rely on more localised agreements e.g. ASEAN agreement on Transboundary Haze.

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, concepts or HL lenses content • 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, concepts and HL lenses content • 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, concepts and HL lenses content • 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.