AP® Environmental Science
2002 Scoring Guidelines

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AP® ENVIRONMENTAL SCIENCE
2002 SCORING GUIDELINES

Question 1

Total Score 10 Points

(a) Identify and describe two <u>environmental</u> benefits to using electric vehicles in place of gasoline-powered engines for transportation. (*4 points maximum*)

The student can earn ONE point for identifying and ONE point for describing each environmental benefit. The description must be linked to the identified benefit. Only the first TWO environmental benefits cited are scored.

Identify (1 point)	Describe (1 point)
Decreased levels of:	
CO	improved human health (must cite specific, accurate, health impact of CO: reduced O_2 transport, headaches, drowsiness, aggravates respiratory problems, coma, brain damage, death); no point for describing global warming due to CO
CO_2	greenhouse gas therefore less global warming, decreased greenhouse effect, decreased acid precipitation (no point for just identifying CO_2 as a greenhouse gas)
SO_2	improved visibility, decreased acid precipitation, decreased property damage, improved human health (must cite specific, accurate, health impact of SO_2: aggravated respiratory problems)
NO_x	improved visibility, decreased acid precipitation, improved human health (must cite specific, accurate, health impact of NO_x: aggravated respiratory problems, increased susceptibility to respiratory infections)
VOCs/hydrocarbons	decreased secondary air pollutants (must cite specific example: PANs, O_3), improved human health (must cite specific, accurate, impact of VOCs: decreased cancer rates, decreased lung irritation)
Particulates (SPM)	improved visibility, decreased property damage, improved human health (must cite specific, accurate, impact of SPMs: respiratory system irritation and damage, aggravated respiratory problems)
MTBE (from gas spills)	decreased groundwater contamination
Specifically identified secondary pollutant, PANs or O_3	must give health/environmental benefit associated with a decrease in the specifically named secondary pollutant

NOTE: A decrease in lead emissions is NOT an acceptable identification for the United States, but IS an acceptable identification for a developing country or a country still using leaded gas. A specific health/ environmental impact of decreased levels of atmospheric lead in that country would earn a description point.

Question 1 (cont'd.)

Decreased use of petroleum leads to:	Results
Decreased release of toxins from refining	improved human health by decreased cancer rates, lung irritation, decreased ecosystem damage/disruption (must cite specific example)
Fewer oil spills, fewer pipeline leaks	less habitat destruction, decreased water contamination, decreased ecosystem damage/disruption (must cite specific example)
Fewer new oil wells, less extraction, fewer pipelines	less habitat destruction, decreased ecosystem damage/disruption (must cite specific example)
Fewer fluid leaks from gas cars	less surface and groundwater contamination (less oil on streets)
Less noise using electric vehicles	improved human health (must cite a specific problem such as hearing loss, less annoyance in high traffic areas), ecosystem disruption with specific example

NOTE: It is NOT ACCEPTABLE for a student to use generic terms for their answer such as the following: air pollution, smog, exhaust emissions, depletion of fossil fuels, non-renewable resource, carbon emissions, or sulfur emissions. A specific identification is required, as shown above, to earn credit.

Question 1 (cont'd.)

(b) Estimate the potential reduction in petroleum consumption (in gallons of gasoline per year) that could be achieved in the United States by introducing electric vehicles under the following assumptions:

The mileage rate for the average car is 25 miles per gallon of gasoline.
The average car is driven 10,000 miles per year.
The United States has 150 million cars.
10 percent of the United States cars could be replaced with electric vehicles.

(*2 points maximum*)

The student can earn ONE point for the correct setup (which must include units), and ONE point for the correct answer. The student is not penalized for failing to include (i) the unit 'cars' in their setup, OR (ii) the unit 'gallons of gasoline per year' in their answer, as these units are already stated in the question. The answer may be written in words and receive full credit.

(150 million cars) × (10,000 miles per year)/25 miles per gallon × 0.1 = 6 billion or 6,000 million

OR
$(150 \times 10^6$ cars) × $(1 \times 10^4$ miles per year)/25 miles per gallon × 0.1 = 6×10^9

OR
(10,000 miles per year)/25 miles per gallon = 400 gallons per year per car
$(150 \times 10^6$ cars) × (.1) = 15×10^6 cars
$(15 \times 10^6$ cars) × (400 gallons per year per car) = 6×10^9 gallons saved

OR
150 million cars × 10,000 miles per year = 1,500,000,000,000 total miles per year
(1,500,000,000,000 total miles per year)/25 miles per gallon = 60,000,000,000 total gallons per year
60,000,000,000 total gallons per year × 0.1 = 6,000,000,000 gallons saved

OR
(10,000 miles per year)/25 miles per gallon = 400 gallons per year per car
400 gallons per year per car × 150 million cars = 60,000,000,000 total gallons per year
60,000,000,000 total gallons per year × 0.1 = 6,000,000,000 gallons saved

OR
150 million cars × 0.9 = 135 million cars
135 million cars × 10,000 miles per year = 1,350,000,000,000 miles per year
1,350,000,000,000 miles per year/ 25 miles per gallon = 54,000,000,000 gallons used per year
(with one of the above showing 150 million cars require a total of 60 billion gallons per year)
60 billion – 54 billion = 6 billion gallons saved

OR
One of the above written in words.

Question 1 (cont'd.)

(c) Some people have suggested that electric vehicles only shift the emission of air pollutants from dispersed sources to point sources. Explain and defend or refute this statement. (*2 points maximum*)

The student can earn ONE point for an explanation and ONE point for EITHER defending OR refuting the statement. The student can receive a point for defending or refuting the statement without having to correctly explain the statement.

Explain (1 point): Gasoline cars must be identified as a dispersed (non-point, mobile) pollutant source, as opposed to electric cars, which obtain energy from an electrical generating power plant (point source, stationary source).

Defend (1 point): Electrical generating source identified as using combustion (oil, coal, natural gas, fossil fuels, biomass).

OR

Refute (1 point): Electrical generating source identified as solar, hydroelectric, nuclear, wind, fuel cells, or other non-combustion sources.

(d) Propose two potential new United States government policies that would encourage the widespread use of electric vehicles. Explain. (*2 points maximum*)

The student can earn ONE point for each EXPLAINED new policy that would result in increased electric vehicle use. Only the first TWO policies cited are scored.

The proposal must include an action by the U.S. government and contain the mechanism for change. For example, increasing the cost of gasoline is not a direct function of the government, except by increasing gasoline taxes or by decreasing energy subsidies. The proposal must be linked to the way in which it would increase the use of electric vehicles.

Incentives for using electric cars:

- tax credits
- tax rebates for purchase of electric vehicle
- special travel lanes/no tolls/reduced tolls
- preferential parking
- supplies recharge stations
- investment in R & D (battery research, charging technology)
- mandated production/sales quotas for electric vehicles
- subsidies to companies that supply electric vehicles
- free electricity/reduced electric rate for owners of electric vehicles
- funding to education programs/advertising that promotes electric vehicles
- subsidized loans for the purchase of electric vehicles

Question 1 (cont'd.)

Disincentives for gasoline vehicles (must explain how it increases use of electric vehicles)

- remove gas subsidies
- increase gas taxes
- increase gas-guzzler tax or surcharge
- emission penalties
- stricter emission standards
- higher fleet miles per gallon/higher CAFE standards
- rationing gas
- limit number of gas cars per family
- phase out/ban gas cars
- mandates production/sales limits for gasoline vehicles
- increase tariffs (taxes on imports) on petroleum
- boycott petroleum imports

NOTE: It is NOT acceptable for a student to simply suggest the following: raise the price of gas, increase or decrease insurance rates, impose full cost pricing (internalization of external costs), reduce price of electric vehicles.

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Question 2

Total Score — Maximum 10 Points

(a) Describe and discuss two environmental problems that are associated with water diversion.

Four points: one point can be earned for each of the first two appropriate descriptions of environmental problems of water diversion (additional descriptions are not scored); one point can be earned for a discussion of each of the environmental problems previously described.

DESCRIPTION	DISCUSSION
Decreased nutrient-rich sediment downstream	Decreases plant growth/decreased NPP/disruption of food chains/webs
Increased salinity with decreased water volume	Decreases plant growth, animal health (e.g., brine shrimp and flies in Mono Lake)
Increased concentration of pollutants that would be diluted without diversion	Such as arsenic, which is toxic to many plants and animals
Decreased populations of migratory birds sustained by the waterway	Such as the piping plover, interior least tern, etc.
Decreased water volume in waterways downstream/below the dam	Results in decreased dissolved oxygen levels in the water, therefore less DO for aquatic organisms to carry out respiration Results in increased water temperature Decreases available downstream habitat, leading to depressed populations, extirpations, extinctions Exposes riverbank soil/accelerated erosion Interferes with reproductive cycles of plants and animals downstream Lowers water tables; saltwater intrusion; land subsidence Decreases recharge of downstream groundwater Decreases volume of nutrient-rich water flow to estuaries, decreases NPP, alters food chains/webs
Decreased water volume/flow rate	Leads to stagnation of remaining water, contributing to lowered DO levels, increased water temperatures
Diversion of water to develop agricultural land	Leads to loss of natural areas and available habitat
Increased water volume by creating a reservoir or by increasing flow volume in a tributary	Results in colder temperatures, which may disrupt fish physiology (enzyme action, etc.)
Flooding behind the dam/flooding by the presence of the reservoir	Wipes out/submerges habitat area/decreases the number of organisms supported by the ecosystem
Habitat degradation in constructing the dam, levee, canal, etc.	Loss of habitat resulting in potential loss of plants and animals

DESCRIPTION	DISCUSSION
Channelization of water	Loss of habitat, fewer nutrients reach these areas next to the channel; fewer organisms supported
Habitat degradation/ decline in air quality	Specific types of pollutants emitted, e.g., CO_2
Fish species may be prevented from reaching spawning/breeding/feeding areas by damming or decreased water volume.	Leading to decreased numbers of the species; (must identify a specific fish species
Decreased sediment downstream of dam	Decrease in sandbar formation/habitat areas for wildlife, such as shallow pools suitable for breeding fish Decrease in nutrients for plant & animal growth
Diverted water used for irrigation that is returned to waterway may contain high levels of nutrients (fertilizers).	Decrease in dissolved oxygen and decrease in number of aerobic organisms Increase in nitrates, phosphates contributing to eutrophication
Irrigation of agricultural fields with water returns to river with increased salinity	Increased salinization of river system, depressed populations, degraded quality of habitat
Increased water volume in areas of diversion projects can suspend pollutants that were held within the soil prior to the increased water volume	Identification of a specific example, e.g., mercury with the James Bay Project
Invasion of exotic/alien species as a result of water diversion	Competition/elimination of native species
Increased water volume resulting in saturation (waterlogging) of soils	Lack of oxygen in soil for plant growth, etc.

(b) If there is a shortage of water, choices will have to be made as to whether water should be diverted to urban areas, agricultural areas, or natural ecosystems. Make an argument for diverting water for urban consumption and an argument for permitting the flow of water to natural areas.

Four points: one point earned for the argument and one point for additional support of the argument. Maximum of two points for urban areas and two points for natural areas.

Definition of "argument" used: "A coherent series of statements leading from a premise to a conclusion" (Merriam Webster, 2002)

Question 2 (cont'd.)

URBAN CONSUMPTION	NATURAL AREAS
Urban areas need water diverted for: domestic uses such as washing clothes, bathing, washing dishes, cooking, drinking water, etc.	Natural areas need water for plant functions: green plants provide natural air filtration and carbon dioxide uptake, plus they provide other benefits, such as cooling
Industrial uses such as in cooling power plants, in paper production, etc.	Wetland areas filter water, removing potential water pollutants, such as excess nitrates, phosphates
Economic impact due to loss of jobs and the inability of industries to function without water, causing economic hardship	
Health: clean/ample water supplies are necessary to prevent spread of disease, maintain hygiene, etc.	Recharge of groundwater supplies surface water as a component of the hydrologic cycle
Agriculture: though agricultural areas are not urban, a significant portion of the world's people (approximately 50 percent), live in urban areas and depend on/consume water indirectly and directly by relying on the productivity of agricultural lands.	Sustaining food chains, providing habitat, maintaining biodiversity of organisms that have important roles in nutrient cycles, etc.
Keeping the cost affordable — if water was not diverted, the cost would increase and be too costly for some people (poorer hygiene and increase in diseases)	Conservation: with more efficient use of water in urban areas, enough water would be available for urban consumption and be allowed to flow to natural areas.
Since approximately one-half of the world's people live in urban areas, urban diversion for water consumption is necessary	Maintaining natural areas for their aesthetic value and recreational purposes
Maintaining nature within urban areas for aesthetic value and ecological services that plants provide	Prevention of continued urban and suburban sprawl
Ethical/moral justifications for the survival of people	Ethical/moral justifications for survival of species in natural areas

(c) Identify another example (other than the Colorado River) of a large-scale water-diversion project. Discuss two environmental problems that have resulted, or might result, from this project. (*3 points*)

Three points: one point is earned by identifying another water diversion project. One point is earned for each environmental problem that might result from the project (maximum of two points). Students must identify a specific water diversion project in order to earn one or all three points. They cannot earn the discussion points unless they have identified a diversion project. Since the question wording ("other than the Colorado River") might direct the student to focus on the name of a specific river and state their answer such as, "the damming of the Nile River", this type of response earns the identification point.

Question 2 (cont'd.)

The two environmental problems discussed must be applicable to the identified water diversion project, and only the first two problems discussed are scored.

Water Diversion Projects (some examples are shown below; although this is not a comprehensive list):

Aswan Dam/Nile River	Amazon River
Three Gorges Dam/Yangtze River	Snake River
Yellow River	Green River
Columbia River	White River
Aral Sea/Amu Darya River and Dyr Darya River	Panama Canal
Kissimmee River	Pasqua River (Costa Rica)
Tennessee Valley Authority	Russian River (California)
Ohio River	Kariba Gorge (Zimbabwe)
Great Lakes (must be a specific Great Lake)	Chapala Lake (Mexico)
California Water Project	Catawba River (NC, SC)
Mississippi River	Gardiner Lake (Saskatchewan)
Tigris-Euphrates Rivers	Hudson River
Mono Lake	Susquehanna River
Rio Grande River	Owens Valley
Missouri River	Arno River (Italy)
Chittenden Lock/Dam	Potomac River

Many environmental problems listed in part (a) may be used in the discussion for this part. There are also some unique environmental problems associated with specific projects that would also be acceptable.

Example of discussion for James Bay (Hydropower)

Hydro-Quebec (1970s) diverted rivers flowing into the James Bay flooding more than 4,000 square miles of tundra and coastal wetlands along the eastern shore of the Hudson Bay. The project will consist of 600 dams, dikes and will block 19 large rivers and create other diversions.

Adverse impacts: 10,000 caribou were drowned in 1984 while migrating; threat of mercury poisoning to native peoples (Cree) on newly flooded land — 66 percent of residents had high levels as per WHO standards; coastal marshes and estuaries were degraded (eel grass already disappeared and is a keystone species); salmon and other anadromous fish were blocked from spawning beds.

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Question 3

Total Score 10 Points

(a) Plot these data on the blank semi-log graph provided below. Draw a smooth curve through the data points to illustrate the overall trend of the data. (*2 points total*)

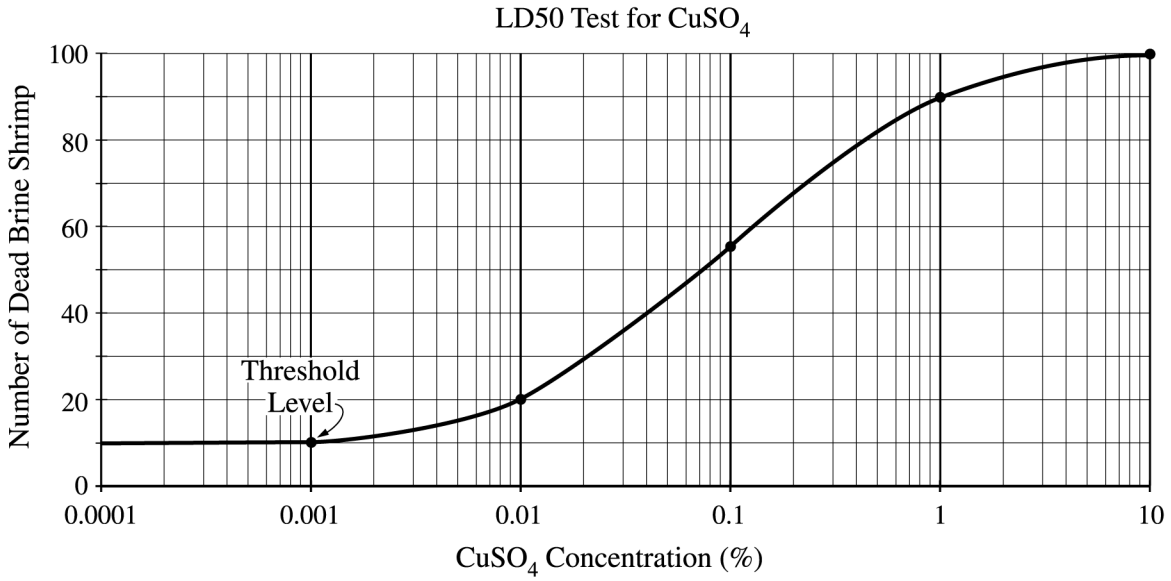
- Plot of data points should be only those points indicated in the data table (see graph below). The only acceptable extra data points must correctly correspond to the student's identification of LD50 and/or threshold level of toxicity. (*1 point*)

  (No data point is included at the beginning of the curve since <0.0001% is technically not a data point though the line of the graph does extend to 0.0001%. However, the students are not penalized for including this as a data point in their graphs.)

- Student draws a smooth, sigmoid curve (see graph below). (*1 point*)

No credit is earned:

- **if student draws line of best fit**
- **if data points are connected with straight segments**
- **if curved lines dip well below 10 between 0.0001% and 0.001% OR well above 100 between 1% and 10% (not consistent with the data)**
- **if student draws more than one line**
- **if the student redraws the graph in the answer section (the directions clearly state that the student is to use "the blank semi-log graph provided below")**



Question 3 (cont'd.)

(b) Explain the meaning of the term LD50 (ED50). What is the LD50 concentration of $CuSO_4$ for brine shrimp? (*2 points*)

Explanation of LD50 (ED50) (*1 point*)

LD50 is the amount or dose of a chemical (toxic substance) that kills half the test population (test organisms/specimens).

OR

ED50 is the amount or dose of a chemical (toxic substance) that causes an observable or undesirable effect or desired symptom in 50 percent of the test population (test organisms/specimens).

If the word "test" is omitted from the definition, students must clearly indicate that the population has been experimentally exposed to a toxin.

No credit is earned for "kills half the 1) species population, or 2) population of a particular species, or 3) population leading to extinction of the species."

Determination of LD50 concentration based on graph (= 0.07 - 0.09%) (*1 point*)

Students must read the value from their graph; answer must be consistent with their graph. The answer is given as a range to accommodate the thickness of the student's pen and the shape of a free-hand smooth curve.

OR

If the graph is done incorrectly, the LD50 must be consistent with the graph they have drawn, but not contradictory to the data as presented in the table. This specific value must be >0.01% and <0.1%.

OR

If students interpret and indicate the 10 dead brine shrimp as the control (natural mortality), then the test population is 90 brine shrimp; 50 percent of this test population would then be 45 brine shrimp. Therefore, according to the graph, the LD50 concentration is equal to 0.1% (which corresponds to the control (10) plus test (45) = 55 dead brine shrimp).

No credit is earned:

- **if the value is stated without a plotted graph (no graph plotted, no credit for second part of (b))**
- **if their answer is not consistent with the line on their graph**
- **if the student responds "less than 0.1%," OR "approximately 0.1%," OR "between 0.01% and 0.1%"**

Question 3 (cont'd.)

(c) Explain the meaning of the term "threshold level of toxicity". What is the threshold level of toxicity of $CuSO_4$ for brine shrimp? Label this point on the graph. (*2 points*)

Explanation of threshold level of toxicity (*1 point*)

The dose (level) below which no toxic (lethal) effects are observed and/or above which the toxic (lethal) effects are apparent.

Determination of threshold level of toxicity (*1 point*)

If students interpret the 10 dead brine shrimp as natural mortality, then 0.001% $CuSO_4$ is the Threshold Level of Toxicity because there is an observable increase in the death of brine shrimp after that concentration. This point must be correctly located and labeled on their drawn curve or on the horizontal axis.

Since the question is worded in such a way that the students might interpret the directions "Label this point on the graph" as the way to answer this part of the question, the numerical value does not have to be included in the written answer as long as it is correctly labeled on the graph.

A point in the range of 0.001% to 0.002% is acceptable as long as it is consistent with their graph and the point at which their graph upturns.

OR

If students do not interpret the 10 dead brine shrimp as natural mortality, then the threshold level is below 0.0001% and therefore they should locate a point to the left of the graph.

No credit is earned:

- **if written numerical value is given without notation on the graph**
- **if student's narrative contradicts or is not consistent with the point plotted**
- **if a student brackets <0.0001 to 0.001 on the graph; this area is the threshold and not the threshold level, which is an identifiable point as asked for in the question**

Question 3 (cont'd.)

(d) Provide one argument for extending these toxicity results to humans and one argument against doing so. (*4 points*)

Definition of "argument" used: "A coherent series of statements leading from a premise to a conclusion" (Merriam Webster, 2002)

In their argument, students must include a thesis statement (*1 point*) linked with one supporting detail (*1 point*) within the context of a paragraph. Any of the statements below may be used either as the thesis statement or the supporting detail. In this context, a complete argument is scored 2 points, an incomplete argument is 1 point, and an invalid or no argument is 0 points.

If students begin their argument with "One argument for extending the testing to humans…" or "One argument against extending the testing to humans…," they have misunderstood the question, which clearly addresses "these toxicity results."

The FOR portion of the rubric will be used to score their FOR argument and the AGAINST portion of the rubric will be used to score their AGAINST argument.

In actuality their FOR argument would match the AGAINST rubric resulting in 0 points; likewise their AGAINST argument would match the FOR rubric also resulting in 0 points. So students earn 0 points if they have misread or misinterpreted the question.

Additionally, if students discuss "publishing the results" or "informing the public" they have also misunderstood what "extending the results" means and receive no points.

If students do not clearly identify their argument as "for" or "against", it will be scored in the order of the presentation of the question — the "for" argument first followed by the "against" argument and the rubric will be applied accordingly.

One argument FOR extending these toxicity results to humans (*maximum 2 points*)

Since the copper sulfate (metal ion) was toxic to brine shrimp, it is reasonable to assume that it might be toxic to humans. (*1 point*)

Copper sulfate is a water soluble toxin and humans are susceptible/exposed to water-soluble compounds. (*1 point*)

Since there is evidence of a dose effect in the brine shrimp, there may be a dose effect in humans. (*1 point*)

Since it may be unethical and/or illegal to test on humans or it might result in injury, harm or death to humans, testing must be done on other organisms. (*1 point*)

These dose-response results can be mathematically extrapolated/estimated and applied to humans. (*1 point*)

This was an experiment conducted under laboratory conditions, therefore the results are verifiable. (*1 point*)

No credit is earned for "Brine shrimp and humans are living organisms".

Question 3 (cont'd.)

<u>One argument AGAINST extending these toxicity results to humans</u> (*maximum 2 points*)

Test animals and humans differ in anatomy, body size, physiology, metabolism, genetics and/or sensitivity, and exposure to toxins. (*1 point for each specified difference*)

Many factors affect the dose-response results — species, sex and age of organism, temperature, synergistic effects, diet, and number of organisms in a cage or container. (*1 point*)

Laboratory conditions do not necessarily reflect actual conditions. (*1 point*)

It is difficult to mathematically predict/estimate these effects on humans. (*1 point*)

Brine shrimp are aquatic organisms and humans are terrestrial. (*1 point*)

A mammalian test population (such as mice or rats) might be more appropriate. (*1 point*)

Dose-response testing only provides data on acute effects and does not address chronic effects. (*1 point*)

The experimental results may not be accurate — sample size too small, only one trial, no control group, error in measurements. (*1 point for each specific inaccuracy*)

Dose-response studies should be conducted on several species before they are applied to humans. (*1 point*)

Just because $CuSO_4$ is toxic to brine shrimp does not necessarily mean it is toxic to humans. (*1 point*)

Documented historic data/incidences on human exposure to $CuSO_4$ might provide more reliable information. (*1 point*)

No credit is earned:

- **for "humans are more complicated (complex) than brine shrimp"**
- **for "humans are different than brine shrimp"**
- **if the student's second argument is simply the opposite of the first argument**

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Question 4

Total Score 10 Points

(a) Describe what an El Niño is and clearly indicate where it occurs.

What an El Niño is: (*2 points*)

If the student takes the description of El Niño directly from the article, then all characteristics in the description must be there in order to earn 1 point.

If the student does not use the description of El Niño from the document, but instead provides a separate description, 1 point can be earned for each characteristic of El Niño (up to 2 points).

Acceptable characteristics include the following:

- Development of warm ocean waters
- Depression of the thermocline, which cuts off the cold water upwelling (or, suppression of upwelling due to diminishing winds)
- Moving of rainfall patterns
- The Northeast and Southeast Trade winds diminish, and sometimes even reverse
- The Southern Oscillation (associated with El Niño) is a switch in atmospheric pressure associated with changing ocean water temperature
- Affects the entire globe/global weather and climate (NOT — "it occurs globally")
- An explanation of the difference between El Niño and ENSO
- An increase in greenhouse gases (global warming) may lead to more frequent/stronger El Niño events (this is also in the document, but was separated from the main part of the definition enough so that it was felt that the student who could connect it to the earlier information should receive additional credit)

Where an El Niño occurs: (*1 point*)

The student earns 1 point if he/she clearly indicates where El Niño occurs.

Acceptable locations for occurrence of El Niño:

- Tropical Pacific Ocean
- Equatorial Pacific Ocean
- Tropical Pacific coast of South America
- Tropical eastern Pacific
- Central and eastern equatorial Pacific

Unacceptable locations include:

- South Pacific
- Southern Hemisphere
- tropical South Pacific
- eastern Pacific
- North America
- Pacific Ocean
- coast of South America

Question 4 (cont'd.)

(b) Describe the connection between the climate change associated with an El Niño and the transmission of diseases. Explain whether the article is correct in its reporting of the various disease epidemics that occur in response to an El Niño.

Connection between El Niño and the transmission of diseases: (*3 points*)

In this part of the question, the student can earn 3 points in several ways by making

- three connections between climate change and disease transmission (this could be a single climate change that can be associated with more than one mode of disease transmission)
- two connections between climate change and disease transmission, plus 1 extended discussion point (see below)
- one connection between climate change and disease transmission, plus 2 extended discussion points (see below)

Climate change: *wetter conditions* promote transmission of disease by:
- increasing the regions where mosquitoes breed — some mosquitoes are carriers of diseases such as malaria, dengue fever, or yellow fever.
- causing flooding, causing a problem because of sanitation (e.g., contamination of water sources with bacteria that may promote the spread of cholera, amoebic dysentery, giardia).

Climate change: *warmer water* promotes transmission of disease because:
- warmer water allows for increased growth of phytoplankton and zooplankton
- bacterial growth increases in warm water
- increased temperatures may mean increased breeding of insects

Climate change: *higher air/land temperatures* promote transmission of disease because:
- higher temperatures give insects (such as mosquitoes) a longer window of reproduction times
- increased temperatures may mean increase breeding and feeding of insects
- higher wintertime temperatures may mean insect populations that carry disease are increased since not as many will be killed by freezes

Climate change: *slightly drier conditions* promote transmission of disease by:
- causing streams to become stagnant, resulting in standing ponds of water that are conducive to increased mosquito populations. (One of the biggest outbreaks of dengue fever in Fiji occurred during the last major ENSO event when Fiji was unusually dry.)

Climate change: *drought* promotes transmission of disease by causing:
- deterioration in fresh water supplies (shortage of potable water; concentration of pollutants in shallow ponds) increases the probability of diseases such as cholera and other diarrheal diseases in places such as Papua New Guinea

Question 4 (cont'd.)

The student can earn up to 2 points for extended discussion/additional information/elaboration such as:

- citing the article, linking global warming with increased ENSO events, that would increase the transmission of disease. The link between more frequent/stronger ENSO events and increased transmission of disease must be explicitly made in order to receive this point.
- if student gives a clear explanation of the differences between vector-borne transmission of disease and other modes of disease transmission

Explain whether the article is correct in its reporting of the various disease epidemics that occur in response to an El Niño: (*1 point*)

1 point for citing the article, in which "scientific evidence" links El Niño and the spread of disease

OR

1 point citing outside sources of information concerning the link of El Niño and disease (i.e., citing the CDC or other "authority") — this can be either in support of the article or disagreement with the article

OR

1 point for noting that only one source is cited in the article and/or that there is not enough information in the article to determine whether or not it is correct

OR

1 point for the student presenting an argument based on their own logic, substantiated by additional information (may be based on the article or on the student's own knowledge)

(c) People in what part of the world would be most likely to be affected by this link between El Niño and disease? (*1 point*)

Although an ENSO event can affect the globe, the areas most likely to feel the greatest impact of increased disease transmission due to climate change associated with ENSO are those areas where (1) the weather/climate changes are most extreme, and (2) health care and sanitation are marginal

1 point for specifying a reasonable area, such as:

Pacific coastal regions of South America and/or equatorial regions of South America (e.g., Peru, Chile, Brazil, Argentina), islands in the tropical Pacific (e.g., Papua New Guinea, Galapagos islands), Central America, Mexico, Southeast Asia, Malaysia, Indonesia, Burma, India, Bangladesh, Pakistan, southern Africa, Kenya

"Developing countries" is also acceptable IF it is coupled with either a reasonable location (e.g., "developing countries in the tropics") OR if the student explains why people in developing countries are more vulnerable to disease (lack of medical facilities, unprepared to handle drastic changes in weather/climate, general population is often malnourished, sanitation is often a problem, etc.)

Unacceptable answers include: North America, Europe, Australia, New Zealand, Canada, United States, polar regions, Antarctica, Arctic (although these areas may be affected by ENSO events, they are not the most likely to be affected by increased disease transmission associated with El Nino)

Question 4 (cont'd.)

(d) Clearly describe two other important environmental problems associated with ENSOs.

(*2 points*)

Only the first two problems stated are graded. Since the question clearly asks for problems associated with ENSOs, the student must demonstrate the connection of the problem with ENSO/climate change. In addition, there must be a completion of cause/effect, and there must be a clear description of how/why this is an environmental problem.

The table below gives some examples of cause and effect. This table is not meant to represent the only ways in which students may make reasonable arguments for environmental problems associated with ENSO. That is, a student does not necessarily need a statement from each column below to make a complete argument. However, the student MUST at least refer to a reasonable change that may be brought about by an ENSO event and a resultant environmental problem. A student cannot, for example, simply say that there will be a loss of biodiversity. They must indicate why there may be a loss of biodiversity, and why the loss of biodiversity may be a problem.

ENSO may cause	Problems (e.g.)	Effects (e.g.)
Warming water (primarily ocean)	Habitat destruction Increased algal blooms Coral bleaching Disruption of migration No upwelling of nutrient-rich waters Die-off of species that cannot tolerate the warmth Lowered water-solubility of CO_2 gas Increased storms/shift of zones where storms form	Starvation/die-off of species Loss of food for higher trophic levels Disruption of food webs Loss of biodiversity
Movement of warm ocean waters/increasing depth of warm surface water	Depression of thermocline Suppression of upwelling Disruption of migration Destruction of habitat	Nutrient-rich waters not available for fish Loss of food Starvation/die-off of species
Increased rainfall	Flooding Mudslides Erosion Nutrient leaching	Habitat destruction Plants unable to grow/loss of food production
Decreased rainfall	Drought/lack of water for living organisms Increased risk of fires Less plant growth	Starvation/die-offs Habitat destruction Starvation/die-offs

Question 4 (cont'd.)

ENSO may cause	Problems (e.g.)	Effects (e.g.)
Increased land temperature	Species unable to adapt Drought	Habitat destruction Starvation/die-offs
Changes in ocean currents	Disruption of migration	Disruption of food webs
Flooding	Loss of habitat Contaminated water supplies Nutrient leaching from soils	Species die-offs Reduced potable water Poor/no plant growth
Drought	Increased risk of fires Lack of water for living organisms Decreased food production	Habitat destruction Decreased food Starvation/die-offs
Increased storms (number, frequency, or strength)	Flooding Increased coastal erosion by waves	Habitat destruction

Unacceptable answers include:

- General weather and/or climate changes that directly affect industries/commerce, such as:
  - Agriculture
  - Construction
  - Property losses
  - Insurance services/financial institutions
  - Outdoor recreation
  - Snow equipment
  - Commercial fisheries
- Any purely economic problem