AP® Environmental Science
2006 Scoring Guidelines

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AP® ENVIRONMENTAL SCIENCE
2006 SCORING GUIDELINES

Question 1

(a) Describe one environmental benefit and one environmental cost of photovoltaic systems.

One point is earned for an environmental benefit:

- Use does not contribute to atmospheric pollution (emission of greenhouse gases, acid rain components, smog, etc.) associated with combustion or geothermal electrical generating systems.
- Use does not contribute to nuclear waste disposal associated with nuclear power facilities.
- Use does not contribute to modification of aquatic habitats associated with hydroelectric facilities.
- Use does not contribute to aquatic thermal pollution associated with steam-producing electrical generating facilities (combustion or nuclear).
- Land disturbance is minimal (little to no destruction of habitats), since most active solar collectors are placed on top of buildings.
- There is less environmental damage compared to the extraction of uranium or fossil fuel resources.

One point is earned for an environmental cost:

- Solar collectors must be manufactured, which uses energy and may contribute to increased atmospheric pollution.
- Production of solar cells produces moderate levels of water pollution.
- Some toxic wastes may be produced when manufacturing cells.
- Disposal of storage batteries (if used) may contribute to water and soil contamination.
- Solar collectors themselves have a limited lifetime and must eventually be replaced (adding to solid waste problem).
- Commercial systems may cause significant habitat disruption due to high land area requirements.
- There are environmental impacts associated with the infrastructure required for commercial photovoltaic systems, such as power lines that fragment habitat.
- There are environmental impacts associated with the extraction/refining of the raw materials necessary to manufacture the photovoltaic cells and batteries.

***One elaboration point is possible for extended description of either identified benefit or cost* (examples):**

- Unlike coal-burning power plants, the use of photovoltaics does not contribute greenhouse gases (such as CO_2) to the atmosphere. These greenhouse gases, in turn, could lead to increased global temperatures.
- The use of photovoltaics does not contribute to thermal pollution of aquatic systems as compared to nuclear or coal-burning power plants. Thermal pollution can lead to decreased levels of dissolved oxygen or cause thermal shock to organisms adapted to cooler water environments.

(b) From the two types of solar systems described on the government Web site, select the system (either stand-alone or grid-connected) that you think best meets the needs of the homeowners. Write an argument to persuade them to purchase the system you selected. Include the pros and cons of each system in your argument.

3 points possible: *Student must clearly indicate their selected system. One point is earned for each supporting statement for either system. Responses cannot earn the maximum of all 3 points unless the number of supporting statements for the chosen system equal or outnumber the supporting statements for the nonchosen system.*

Question 1 (continued)

	Pros	Cons
Grid-connected	There is a back-up energy source in case the home system does not provide enough. Less area is needed for system compared to stand-alone systems. Battery system is unnecessary. Surplus energy can be sold back to the local power company. System can be smaller than stand-alone since the grid can supply energy at peak usage times. Altruistic argument: Excess energy sold back to the utility decreases the need for consumption of other natural resources.	Net-metering hardware (grid exchange system) may be expensive. No battery back-up in case of power grid failure. Utility may require a large system for net-metering capability.
Stand-alone	Does not require the installation of grid-exchange equipment. Completely independent of the electrical grid.	Net metering is not available. May require additional secondary electrical-generating systems for reliability or peak demand. Limited battery storage capability may require secondary electrical-generating systems. A large area may be needed for cells in order to meet energy demands for the house.

(c) Describe TWO ways that government or industry could promote the use of photovoltaic power systems for homeowners in the future.

Two points: *One point is earned for each for the first two answers (must specifically address the increased use of photovoltaics, not just decreased energy use).*

Government

- Provide information/education to homeowners about the benefits of pv systems.
- Give tax credits to homeowners that use pv systems.
- Subsidize the cost of pv panels so that they are cheaper for homeowners to purchase.

Question 1 (continued)

- Appropriate additional funds for research and development into solar cell technology to make pv systems more cost-effective.
- Provide tax breaks for companies that produce the cells, potentially making them cheaper to the consumer.
- Require power companies to have net metering for all homes on a grid-connected system.
- Offer low-interest loans to homeowners to purchase pv systems.
- Mandate the use and installation of pv systems for new home construction.

Industry

- Lower the cost of pv panels/systems.
- Provide information/education to homeowners about the benefits of pv systems.
- Offer low-interest loans to homeowners to purchase pv systems.
- Develop more aesthetically pleasing systems.
- Subsidize the cost of grid-connection equipment.
- Purchase excess electricity generated using photovoltaics at a premium rate.
- Allocate additional resources for research and development into solar cell technology to make pv systems more cost effective.

(d) Describe TWO ways that homeowners could use passive solar designs and/or systems and, for each way, explain how it would reduce the homeowners' energy costs.

Four points: *One point is earned for each action utilizing passive solar design/systems, and 1 point each is earned for each explanation of how the identified design/system would reduce energy costs.*

General Type	Action	Energy Cost Benefit
Solar Obstruction Systems (SOSs)—Any device that prevents or reflects solar radiation from entering the dwelling	Plant trees/shrubs around dwelling (or "on" in the case of rooftop gardens)	• In temperate zones, deciduous trees in the winter will not have leaves so sunlight can shine into the house, warming it. In the summer, the trees will have leaves and will shade the house from sunlight, keeping it cooler. In both seasons, the trees will help keep the heating and cooling costs down. • In sub-tropical zones, trees and shrubs block solar radiation from reaching the house resulting in lower cooling costs year round.
	Reflective roof or wall materials	Decreases cooling costs.
	Window treatments (reflective or blocking)	Decreases cooling costs.
	Build a berm around the house blocking sunlight	Decreases cooling costs.
	Increase insulation in walls and/or use super-insulated windows	Insulated walls and/or windows prevent transfer of heat into the house in the summer, thus reducing cooling costs.

Question 1 (continued)

General Type	Action	Energy Cost Benefit
Building Design Elements	Orientation/siting of house to maximize solar input during colder months	Decreases heating and lighting costs.
	Orientation/siting of house to minimize solar input during warmer months	Decreases cooling and lighting costs.
	Daylighting—the installation of skylights, solar tubes, clerestory windows	Decreases expenses associated with lighting.
	Installation or use of solar oven technology	Decreases costs associated with cooking and cooling.
	Window overhangs and awnings	Can block sunlight during the summer but will allow sunlight in the house in the winter (when the sun is lower in the sky). This helps keep the house cooler in the summer and warmer in the winter reducing the need for air conditioning and heating.
	Use of Thermal Mass Devices (TMDs) such as stone or concrete floors and walls, Trombe walls, interior water reservoirs, etc.	Thermal mass devices store thermal energy during the day and release it at night. This reduces costs associated with heating.
	Installation of a solar chimney	Helps improve ventilation in the house and reduce cooling costs.
	Installation of a roof pond	Promotes evaporative cooling, reducing cooling costs during the summer.
	Installation of a solar water heater (must be nonmechanical)	Decreases costs associated with water heating.
	Removal of vegetation to allow increased solar input into house	Decreases lighting and heating costs.

Question 2

(a) Answer the following questions that relate to the graphs above. Remember that for any calculations you must clearly indicate how you arrived at your answer. Answers must also include appropriate units.

(i) Determine the net change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(*1 point possible*)

Point is earned for the correct set-up and answer, with numbers shown, and units included.

Note: *Lines drawn to x and y-axes were accepted in place of explicit calculation set-up.*

140,000 years before present: CO_2 ~ 200 ppm (accepted range ~195-205 ppm)

125,000 years before present: CO_2 ~ 280 ppm (accepted range ~270-290 ppm)

280 ppm – 200 ppm = an increase of 80 ppm (accepted range 65–95 ppm).

(ii) Calculate the ratio of the change in mean global temperature to the change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(*2 points possible*)

One point is earned for the correct temperature change calculation showing numbers and including units.

Note: *Lines drawn to x and y-axes were accepted in place of explicit calculation.*

Temperature 140,000 years ago ~ – 8°C (below present)

Temperature 125,000 years ago ~ +2°C (above present)

2°C - (-8°C) = an increase of 10°C (range 8.5°C–11.5°C).

1 point is earned for the correct calculation of ratio of temperature to CO_2 concentration change.

Note: *No penalty for ratio calculation based on incorrect answer(s) from above. Range must be consistent with previous values. Percentages not accepted.*

Acceptable answers include 10:80 or 10/80 or 10 to 80; 1:8 or 1/8 or 1 to 8.

(iii) Scientists predict that between 1950 and 2050, the atmospheric CO_2 concentration will increase by 200 ppm. Predict the change in mean global temperature between 1950 and 2050 using the ratio that you calculated in part (ii).

(*1 point possible*)

Point is earned for the correct set-up and answer with correct units.

Note: *No penalty if student uses incorrect calculation(s) from above, as long as values are applied correctly. Range must be consistent with previous values.*

200 ppm × 1°C/8 ppm = 25°C increase in global temperature (accepted range 18°C–34°C)

Question 2 (continued)

(iv) Describe one major assumption that was necessary to make the prediction in part (iii) above. Discuss the validity of the assumption.

***(2 points possible*)**

One point is earned for a correct assumption and 1 point is earned for an appropriate discussion of the validity of the assumption.

Assumption	Validity of Assumption
Direct relationship exists between CO_2 and temperature.	Invalid due to anthropogenic increase of other GHGs and/or precursors. • CH_4, O_3, N_2O, CFCs, HCFCs, HFCs, halons, NO_x , NO, NO_2 , CO, VOCs, HCs Invalid due to negative feedbacks. • Aerosol increase offsets warming • Clouds can offset warming Invalid due to positive feedbacks. • Clouds can enhance warming Invalid because temperature change leads CO_2 concentration change. Invalid because correlation does not remain constant over time series period. Valid because this has been the case for past 200K years (must refer to time series). • Correlation remains constant over time
CO_2 is the only GHG that impacts temperature.	Invalid due to anthropogenic increase of other GHGs and/or precursors. • CH_4, O_3, N_2O, CFCs, HCFCs, HFCs, halons, NO_x , NO, NO_2 , CO, VOCs, HCs Valid because this has been the case for past 200K years. • Correlation remains constant over time
Change expected to occur over a very short time period.	Invalid because uncharacteristically large changes relative to time series scale: • nonlinear fluctuations • correlation changes over time

Question 2 (continued)

Assumption	Validity of Assumption
200 ppm CO_2 concentration change (prediction used as assumption).	Invalid because the change may be greater or less than this value.
Increasing CO_2 concentrations cause atmospheric temperature to rise.	Invalid because time series shows periods when change in temperature leads the change in CO_2 concentration. Valid because time series shows periods when change in CO_2 concentration leads the change in temperature.
Antarctic data can be applied to assume global temperature changes.	Invalid because there are regional variations in the magnitude of temperature fluctuations over time.
Measurement techniques are precise.	Valid because of scientific consensus of data. Invalid because of measurement uncertainty.

(b) Identify and describe TWO major causes for the predicted 200 ppm increase in atmospheric CO_2 concentration between 1950 and 2050.

(*2 points possible*)

One point is possible for each major cause of CO_2 increase identified if linked with an appropriate description.

- Continuing burning of fossils fuels by a growing population
- Increased per capita usage of fossil fuels
- Increased fossil fuel use for energy production
- Increased fossil fuel use for transportation
- Increased fossil fuel use for industry
- Increased ocean temperature results in release of dissolved CO_2
- Land-clearing and burning for increasing food production
- Deforestation (even though this involves the cycling of existing carbon, deforestation is indicated as a CO_2 sink in the texts and is accepted)
- Lack of development of alternative energy solutions

(c) Identify TWO gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature. For each gas, describe a major human activity that leads to its release.

(*2 points possible*)

One point is possible for each gas that contributes to an anthropogenic increase in mean global temperature IF linked to an appropriate description of a major human activity that leads to the release of that gas.

Note: *Increased atmospheric water (H_2O) vapor is not a direct result of human activity.*

Question 2 (continued)

Greenhouse Gas	Human Activity
Methane (CH_4)	Production of rice Landfill use Cattle/sheep ranching Creation of wetlands/bogs Leaks from pipelines, refineries, and coal mines *No credit earned for CH_4 escapes from melting permafrost because melting is not a direct result of human activity.*
Ozone (O_3)	Photochemical smog resulting from internal combustion engines, vehicle exhaust
Nitrous oxide (N_2O)	Burning of petroleum products, biomass, nitrogen-rich fuels (particularly coal) Fertilizers Feedlots (CAFO and/or CAFL) and dairy farms
CFCs (freons), HFCs, and HCFCs	Used in refrigerators and air conditioners, in foam production, to clean electronics, and formerly as propellants
Halons	Used in fire extinguishers

Greenhouse Gas Precursor	Human Activity
NO, NO_2, (NO_x)	Coal burning, internal combustion engines (fossil fuels too generic)
CO	Incomplete combustion of fossil fuels
VOCs	Gasoline/petroleum evaporation Paints and solvents Aerosols
HCs	Gasoline/petroleum • incomplete combustion • evaporation

Question 3

(a) Assume that the city council chooses the first option. Describe TWO problems that result from removing the contaminated soil from the brownfield.

(*2 points possible*)

One point is earned for describing each problem associated with removal of the contaminated soil.

ACCEPTABLE PROBLEMS

- High cost of removing/cleaning/replacing large amounts of soil
- Need to find a place to dispose of contaminated soil—may only move the problem from one site to another
- Erosion at the site
- Ecological disturbance of the area
- Risks from transporting contaminated soil
- Exposure of workers or residents to contaminants (airborne)
- Groundwater contamination remains a problem

(b) Assume that the city council chooses the second option. Explain how vegetation could be used to decontaminate the soil. Discuss one advantage and one disadvantage of using this reclamation method.

(3 points possible)

One point is earned for explaining how vegetation can be used for soil decontamination, 1 point is earned for one advantage of using plants to decontaminate the soil, and 1 point is earned for one disadvantage of using plants to decontaminate the soil.

CORRECT VEGETATION USAGE

When vegetation is planted on a brownfield, the plants take up the contaminants (along with water and nutrients) from the soil.

Advantages of Using Plants	Disadvantages of Using Plants
• Low cost. • Reduces soil erosion. • Reduces the amount of material that has to be taken to a landfill. • Less habitat disruption (not removing the soil). • Aesthetically pleasing.	• Process may be slow. • Vegetation may become hazardous to insects or animals that feed on it. • When the vegetation is removed, it is still hazardous. • May not remove all of the contaminants /effective only to the depth that the roots reach. • May introduce exotic species. • Appropriate plant species may be difficult to grow on the site. • Volatilized compounds may be emitted through plant pores.

Question 3 (continued)

(c) Describe and explain one environmental benefit and one societal benefit of brownfield reclamation.

(2 points possible)

One point is earned for one environmental benefit, and 1 point is earned for one societal benefit.

ACCEPTABLE ENVIRONMENTAL BENEFITS

- Creates green spaces—habitat for plants, insects, animals
- Reduces hazardous runoff into streams, lakes, rivers
- Reduces groundwater contamination
- Reduces urban sprawl by reclaiming urban land

ACCEPTABLE SOCIETAL BENEFITS

- Cleaned up area improves property values
- Can provide green space for parks, athletic fields, or aesthetic value
- Can provide area for housing, businesses, or crops
- Land made available for development can add to tax base and provide jobs
- Decreases health risks related to living near a brownfield
- Use as a positive model for successful reclamation which could increase environmental awareness/community service
- Reduces urban sprawl (if not credited above)

(d) Identify and describe

(i) one method currently used to reduce the production of hazardous waste and
(ii) one method of legally disposing of hazardous waste.

(4 points possible)

Two points can be earned for each section. In part (i), 1 point can be earned for correctly identifying one current method, and 1 point can be earned for describing that method. In part(ii), 1 point can be earned for correctly identifying one current method, and 1 point can be earned for describing that method.

Question 3 (continued)

(i) One method currently used to reduce the production of hazardous waste

Acceptable Method of Reduction	Acceptable Description of Reduction
Recycling, reuse of materials	• Reusing the waste for another application • Establishing trading centers where leftover paint, solvents, pesticides, or cleaning solutions are reused • Reusing batteries (rechargeable) • Gas stations accepting oil for recycling
Substitution of nonhazardous materials for hazardous materials	Using a less toxic material • Acetamide—Substitute: Stearic acid • Chromic acid cleaning solutions—Substitute: Detergents Formaldehyde—Substitute: Ethanol • Mercury thermometers—Substitute: Alcohol thermometers
Government regulation of the contaminant	• Prohibition of PCBs, CFCs, DDT • Specific limitations or acts/laws/regulations (EPA: RCRA) • Pollution prevention act • Monitoring for compliance • Pollution credits, tax credits, or trading credits • Requiring the use of catalytic converters
Substitution of alternate energy sources that do not produce hazardous wastes	Wind, solar, hydroelectric, or geothermal
Becoming more efficient in the manufacturing process	Specific examples of increased efficiency

Question 3 (continued)

(ii) One method of legally disposing of hazardous waste

Acceptable Legal Method of Disposal	Acceptable Description of Legal Disposal of Hazardous Wastes
Incineration	Burning waste plus one of the following: • reduces volume • detoxify the waste • may produce air pollution
Bioremediation	Using organisms to decompose the contaminants.
Chemical methods	Detoxification or stabilization before disposal, vitrification of nuclear wastes (glass rods)
Landfills	Description of the site to include at least one of the following: • lined • contained • sealed drums
Deep well injection	Injection of hazardous wastes into underground sites that are geologically stable
Exportation of wastes	Ship to a less regulated country
Utilize a local hazardous waste collection site (only 1 point)	Must include specific details about the collection or the site. Must specify that there is a local site.
Name of a specific disposal site (e.g., Yucca Mountain)	Description of the site must include at least one of the following: • monitored for leakage • geologically stable • isolated from population centers
Surface impoundments	Lined liquid disposal pits

Question 4

(a) Identify the five-year period during which the greatest rate of decline in the fish harvest took place. For that five-year period, calculate the rate of decline in the fish harvest, in metric tons per year. Show clearly how you determined your answer.

(2 points possible)

One point is earned for correctly identifying the time period, and 1 point is earned for showing the calculation. The student may earn the second point by describing in words how he or she arrived at the final answer.

Time period of greatest decline: 1965–1970

$(700 \times 10^3$ metric tons $- 200 \times 10^3$ metric tons) / 5 years = 100,000 metric tons/year

Acceptable range: 100,000–102,000 metric tons/year (no credit earned for 1970 value $< 190 \times 10^3$ metric tons)

(b) Choose any TWO commercial fishing practices from the list below. For each of your choices, describe the practice and explain the role it plays in the depletion of marine organisms.

(4 points possible)

One point is earned for each description, and 1 point is earned for a brief explanation of how the practice contributes to depletion. Each bulleted contribution in the table below is an acceptable answer.

Question 4 (continued)

Method	Description of Practice	Contribution to Depletion
Bottom trawling	Drag a net along ocean bottom ***OR*** Drag a line with hooks along bottom	• Catches many nontarget species* (bycatch) • Benthic habitat destruction
Long-line fishing	Fishing line with many hooks, extending for long distances and allowed to drift ("towed" not credited)	• Catches many nontarget species (bycatch) • Ghost fishing (continue to catch even when untended)
Nets -Drift nets/Gill nets OR---------- -Purse seines	Large nets, stretching for miles and set out and allowed to drift ("towed" not credited) ---------- Large nets are drawn up like a drawstring purse to capture fish in large schools near the ocean surface ("towed" not credited)	• Mesh size may selectively deplete certain size/age class • Catches many nontarget species (bycatch) • Ghost fishing (continue to catch in untended net) ---------- • Catches large quantities of fish (whole schools) • Catches many nontarget species (bycatch)
Sonar	Sound waves used to locate fish or to "see" the bottom	• Allows ships to locate large schools relatively quickly • Targets specific species

* *Nontarget species* include noncommercial species;
individuals of illegal size or age; species caught out of season

Question 4 (continued)

(c) Identify one international regulation or United States federal law that applies to the harvesting of marine food resources and explain how that regulation or law helps to manage marine species.

(1 point)

Point can be earned for naming a specific, relevant international regulation or federal law and for a brief explanation of how it helps manage marine species.

A number of specific international regulations and federal laws are acceptable if the law cited relates to the harvesting of marine resource. The student must provide a correct explanation of how the regulation or law helps manage marine species. The most common answers are given below.

Note*: Abbreviations alone are acceptable only for the Endangered Species Act (ESA) and the Convention on International Trade in Endangered Species (CITES).*

Endangered Species Act/ESA—prohibits the harm or harvesting of endangered species; protects habitats

Marine Mammal Protection Act—protection and conservation of marine mammals

Convention on International Trade in Endangered Species/CITES—prevents trade of threatened or endangered marine species

Magnuson-Stevens Fisheries Management and Conservation Act (Magnuson Act)—establishes Regional Fisheries Management Councils that set quotas, size limits, and seasons; establishes 200-mile fishing area; protects essential habitat; rebuilds overfished stocks; minimizes bycatch

UN Law of the Seas—individual countries have jurisdiction over Exclusive Economic Zones (200 miles off shore) and sovereignty over the sea bed 12 miles offshore; allows for Individual Transferable Quotas (ITQs) in which allocated quotas can be sold to others

International Whaling Commission/International Convention for the Regulation of Whaling—regulates the species that can be harvested and sets quotas on the number of cetaceans that can be harvested

Other U.S. and International Laws and Regulations Accepted:

The Oceans Act of 2000—establishes a presidential commission to examine federal ocean policies and programs; promotes protection of marine environment and prevention of marine pollution

U.S. Whale Conservation and Protection Act—prohibits the harvesting of whales in U.S. waters

Marine Sanctuaries Act—protects the habitat for marine organisms and protects the animals from being harvested in that area

Question 4 (continued)

Fur Seal Act of 1966—prohibits taking of fur seals or use of U.S. ports and harbors for vessels illegally taking fur seals; allows for subsistence hunting by native people; manage fur seal rookeries in the Pribilof Islands

Lacey Act of 1900—prohibits sale of illegally harvested species; forces fisherman to harvest legally

(d) The oceans of the world are often referred to as a commons. Give an example of one other such commons, explain how human activities affect that commons, and suggest one practical method for managing that commons.

(3 points possible)

One point can be earned for correctly identifying a commons. One point can be earned for briefly explaining how a human activity affects the specific commons. The student can earn 1 point for citing a practical method of management linked to the identified commons.

ACCEPTABLE COMMONS: ***1 point***

- Atmosphere/Air
- Groundwater/Aquifers
- National Forests/National Parks
- Antarctica
- Estuaries
- Great Lakes
- Rivers and Streams
- A variety of other resources may be accepted as a commons ***IF*** the student clearly demonstrates that it is a public resource being used privately

HUMAN ACTIVITIES: ***1 point—must be linked to the chosen commons***

- A human activity and brief explanation of how that activity degrades the selected commons can be accepted (e.g., fossil-fuel combustion increases greenhouse gases in the atmosphere).

PRACTICAL MANAGEMENT METHODS: ***1 point—must be linked to the chosen commons***

- Any specific management suggestion that is practical and linked to the chosen commons can be accepted.

Some answers that may apply to many commons:

- Education of the public—must relate to a specific problem (e.g., teaching about forest fire prevention).

- Regulations, enforcement, agencies—must be directed at a specific problem.