AP® Environmental Science
2010 Scoring Guidelines

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Question 1

(a) Choose any ONE of the three pollutants mentioned above and respond to each of the following.

(i) Describe one specific source, other than the local chemical plants, for the toxic pollutant you chose.

One point can be earned for the description of a specific source of the pollutant. (Only the first answer is scored.)

PCBs	Mercury	Lead
• Transformers • Miscellaneous electronics • Hydraulic systems • Gas pipelines • Mining equipment • Lubricants • Pesticides • Wood treatments • Printing ink • Paint • Carbonless copy paper • Plastic • Waste oil • Roofing materials	• Coal burning • Gold mining • Thermometers • Barometers • Thermostats • Compact fluorescent lightbulbs • Switches • Appliances • Dental amalgam (fillings) • Use of Hg in cultural and religious practices • Batteries • Jewelry • Fungicides • Mine waste containing mercury	• Paint • Water pipes • Lead glaze on ceramics • Gasoline additives • Lead bullets and shot • Cosmetics • Jewelry • Traditional foods and medicines • Batteries • Electronics • Mine waste containing lead • Smelting

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Question 1 (continued)

(ii) Describe how the pollutant you chose enters the human body and one specific effect it can have on human health.

Two points can be earned: 1 point for describing how the pollutant enters the human body and 1 point for describing one human health effect of the pollutant.

How the pollutant enters the human body (Only the first answer is scored.)		
PCBs	**Mercury**	**Lead**
• Ingesting seafood contaminated with PCBs • Inhaling dust contaminated with PCBs • Absorption through skin • Drinking contaminated water	• Ingesting seafood contaminated with mercury • Ingesting food or water contaminated by soil, mine waste or particulates containing mercury • Inhaling mercury vapors (from broken thermometers, barometers, compact fluorescent lightbulbs, etc.) • Absorption through skin • Medical and dental procedures	• Ingesting food or water from ceramic tableware produced with lead-containing glazes • Ingesting food or water contaminated by soil, mine waste, particulates or plumbing containing lead • Ingesting lead-based paint • Inhaling dust or vapors contaminated with lead

Human health effects (Only the first answer is scored.)		
PCBs	**Mercury**	**Lead**
• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Damage to the reproductive system • Feminization • Low sperm counts • Hermaphroditism • Cancer	• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Reproductive system damage • Feminization • Low sperm counts • Hermaphroditism • Kidney damage • Hearing loss • Minamata disease • Autism* * While controversial, published studies have suggested a link between mercury and autism.	• Birth defects • Nervous system damage • Brain damage • Learning disabilities • Mental retardation • Paralysis • Attention deficit disorder • Kidney damage • Hearing loss • Anemia • Liver or stomach damage

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Question 1 (continued)

(iii) Describe TWO specific steps, other than an outright ban, that a city or nation can take to reduce the threat posed by this pollutant.

Two points can be earned: 1 point for each specific step that will reduce the threat posed by the pollutant. (Only the first two answers are scored.)

PCBs	Mercury	Lead
• Educate people about how to avoid PCBs	• Educate people about how to avoid mercury	• Educate people about how to avoid lead
• Substitute safer alternatives for PCBs	• Substitute safer alternatives for mercury	• Substitute safer alternatives for lead
• Replace products that contain PCBs with different products	• Replace products that contain mercury with different products	• Replace products that contain lead with different products
• Collect and safely dispose of products containing PCBs	• Collect and safely dispose of products containing mercury	• Collect and safely dispose of products containing lead
• Set and/or enforce policies that limit the production, use and discharge of PCBs	• Set and/or enforce policies that limit the extraction, production, use and discharge of mercury	• Set and/or enforce policies that limit the extraction, production, use and discharge of lead
• Phytoremediation of contaminated areas	• Phytoremediation of contaminated areas	• Phytoremediation of contaminated areas
• Treat water supplies to remove PCBs	• Treat water supplies to remove mercury	• Treat water supplies to remove lead
• Restrict fishing for species known to have high PCB concentrations	• Restrict fishing for species known to have high mercury concentrations	• Remove, cap or contain mine waste with high lead concentrations
• Dredge contaminated waterways	• Remove, cap or contain mine waste with high mercury concentrations	• Remove, cap or contain soils with high lead concentrations
• Wash contaminated soil	• Use technology to remove mercury from coal and smokestacks	• Remove lead-based paint from painted surfaces
• Incinerate contaminated soil	• Reduce coal burning	
	• Clean up mercury spills	

Question 1 (continued)

(b) Give one reason why Dr. Egguen is correct in asserting that children are particularly susceptible to toxic pollutants.

One point can be earned for a correct reason that children are particularly susceptible to toxic pollutants. (Only the first answer is scored.)

- Children take in more water, food and air per unit of body weight than adults.
- Children often put dirty objects or hands in their mouths.
- Children have less developed immune systems.
- The liver of a child does not metabolize pollutants as efficiently as the liver of an adult.
- The growing organ systems of children are more sensitive to pollutants than the mature systems of adults.
- Children will accumulate pollutants for a longer period of time than adults.

(c) An important contributor to global climate change is the release of CO_2 from the rapidly increasing number of coal-burning power plants in China. Assume that the coal burned at these plants to provide the power to manufacture a single MP3 player releases 40 kg of CO_2 and that it costs $0.75 to capture 1 kg of CO_2 and keep it from entering the atmosphere. Determine the cost, in dollars, to capture the total amount of CO_2 released from manufacturing one MP3 player.

Two points can be earned: 1 point for a correct setup and 1 point for the correct answer. (Units are not required.)

$$40 \ \cancel{\text{kg CO}_2} \times \frac{\$0.75}{1 \ \cancel{\text{kg CO}_2}} = \$30$$

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Question 1 (continued)

(d) Coal-burning power plants also release other pollutants, including nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulates. Select one of these pollutants and identify one technology that can be used to remove it from the waste stream of coal-burning power plants.

One point can be earned for identifying a correct technology for the pollutant selected.

NO_x	SO_x	Particulates
• Coal gasification • Fluidized-bed combustion • Burning pulverized coal at reduced temperatures • Selective catalytic reduction	• Coal gasification • Fluidized-bed combustion • Scrubber • Removal of sulfur prior to burning coal	• Coal gasification • Fluidized-bed combustion • Scrubber • Filters • Baghouse filter • Electrostatic precipitator • Cyclone separator

(e) Discuss TWO reasons why a multinational company would choose to build a manufacturing facility in India and/or China rather than in the United States or Europe.

Two points can be earned: 1 point for each correct reason that is discussed. (Only the first two answers are scored.)

- Less stringent environmental regulations
- Lax enforcement of environmental regulations
- Less expensive labor
- Large populations of workers willing to work for lower wages
- Fewer workplace regulations
- Lower health-care costs for workers
- Less expensive property
- Less expensive raw materials
- Lower/fewer taxes and fees
- Government subsidies
- Lower litigation costs
- Expansion of markets

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Question 2

(a) Respond to the following using the data in the table above, which gives the rate of wood consumption by termites, in mg per day per termite, under various temperature and relative humidity conditions. Under optimal conditions, the emission rate of methane by termites is approximately 70 kilograms of CH_4 per year per 1,000 termites.

(i) According to the data, what are the optimal temperature and relative humidity for termite activity?

One point can be earned for correctly identifying the optimal temperature (30°C) AND relative humidity (90 percent).

(ii) Given a density of 4.5×10^7 termites per hectare and optimal conditions, calculate the annual amount of methane emitted, in kilograms, by the termites inhabiting a 2,000-hectare tropical rain forest.

One point can be earned for a correct setup (all units must be included), and 1 point can be earned for correctly calculating the amount of CH_4 produced per year. (Units are not required in the answer, but the student must show the calculation in order to receive the answer point.)

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups and arrive at a correct answer will also earn a point. Equivalent correct answers (e.g., 6,300,000,000 kg CH_4/year) are acceptable.

$$2{,}000 \text{ hectares} \times \frac{4.5 \times 10^7 \text{ termites}}{1 \text{ hectare}} \times \frac{70 \text{ kg } CH_4 / \text{year}}{1{,}000 \text{ termites}} = 6.3 \times 10^9 \text{ kg } CH_4 / \text{year}$$

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Question 2 (continued)

(iii) Suppose the temperature increases to 35°C and the relative humidity decreases to 50 percent. Using the data provided, determine the amount of methane, in kilograms, that would be emitted by the termites in the 2,000-hectare tropical rain forest.

One point can be earned for a correct setup, and 1 point can be earned for correctly calculating the amount of CH_4 produced per year (units are not required in the answer). Because this calculation could reasonably be done in a student's head, this answer point can be earned without a setup.

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups that produce a correct answer will also earn a point.
Equivalent correct answers (e.g., 21,000,000,000 kg CH_4/year) are acceptable.

$$\frac{0.09}{0.27} \times 6.3 \times 10^9 \text{ kg } CH_4\text{/year} = 2.1 \times 10^9 \text{ kg } CH_4\text{/year}$$

(iv) Explain why the population size of the termites is also affected by temperature and humidity.

One point can be earned for a reason, and 1 point can be earned for an explanation. The reason and the explanation must be correctly linked; however, students can earn an explanation point without earning a reason point.

Reason	Explanation
• Temperature and humidity are limiting factors for the termite populations and/or their symbionts. • There is a range of tolerance for temperature and humidity values for termites and/or their symbionts.	• At temperatures of 40°C, all termite wood consumption ceases; and at 20°C, activity is at its lowest regardless of relative humidity values. • At 40°C, the symbionts living in the termite's gut may die. • At relative humidity levels less than 90 percent, termite wood consumption declines regardless of temperature.
Termites reproduce less when conditions are not optimal.	Termites swarm less, and fewer new colonies are established.
Temperature and humidity are limiting factors for plant growth and survival.	With fewer plants available, less food will be available and termite numbers will decline.

Question 2 (continued)

(b) It has been observed that soon after a tropical rain forest is cleared, termite density increases to an estimated 6.8×10^7 termites per hectare. Thereafter, the termite population size decreases dramatically.

One point can be earned in part (i) for the most likely reason, and 1 point can be earned in part (ii).

(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

- When the forest is first cleared, there is a substantial increase in dead plant material.
- The food source for the termites has dramatically increased and supports a larger population of termites.

(ii) Why do the termite populations eventually decrease dramatically?

- The termites exhaust their food supply and die off due to a lack of food.
- The termite population exceeds the carrying capacity of the forest, and the population crashes.
- With no trees, the surface temperatures increase and may exceed the upper temperature limit at which termites can survive.
- There is competition for a limited resource.

Question 2 (continued)

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

One point can be earned for stating a correct change, and 1 point can be earned for describing the response. The change and the response must be correctly linked. Students can earn a response point without earning a change point.

Change	Climate Response
Reduction in photosynthesis.	Less CO_2 is removed from the atmosphere, increasing the concentration of CO_2, a greenhouse gas, in the atmosphere.
Loss of a carbon sink.	Increased amounts of CO_2 and/or CH_4, greenhouse gases, are released into the atmosphere.
Slash/burn removal of trees.	Increased amounts of CO_2 and N_2O, greenhouse gases, are released into the atmosphere.
Lack of shade.	Warmer surface temperatures.
Reduction in evapotranspiration.	• Loss of cooling effect (atmospheric cooling) from water evaporating. • Drier climate can result in forest fires in other areas, releasing more CO_2 and N_2O, greenhouse gases, into the atmosphere.
Bulldozers, chain saws, and trucks, which are used to remove trees, consume fossil fuels.	CO_2, a greenhouse gas, is released into the atmosphere.
Increase in albedo.	More energy is reflected from the surface.

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Question 3

(a) Why are zebra mussels located primarily in areas in the eastern United States rather than in the western United States?

One point can be earned for any acceptable explanation:

- The animal was introduced in the eastern U.S. and is still spreading across the continent.
- The eastern states have more surface waters available for colonization and to act as corridors to dispersal; the western states have fewer such habitats.
- The western mountain ranges (e.g., the Rockies) serve as a natural barrier to dispersal.
- Humans spread the animal, and human population density is generally higher in the East.

(b) How are zebra mussels introduced into isolated lakes? Describe one viable method for preventing the spread of zebra mussels into isolated lakes.

Two points can be earned: 1 point for a mechanism by which the mussels are spread and 1 point for a method to prevent mussel introductions. The two responses need not be linked.

Mechanisms of zebra mussel introduction

- Transport of boats or boat trailers with mussels attached
- Carried in water in boats (excluding ballast, which implies oceangoing vessels)
- Inundation of isolated lakes with floodwater containing mussels
- Building canals or other waterways between previously isolated lakes
- Transport by animal vectors (migratory waterfowl, etc.)
- Brought with fish used to stock water bodies

Methods to prevent spread of zebra mussels

- Thorough inspection/cleaning of boats before transport or launch
- Flushing or draining of water between water bodies
- Refraining from building connecting waterways
- Education/information campaigns to discourage practices causing spread
- Prohibiting transport of boats to unaffected lakes

Question 3 (continued)

(c) Identify and explain one impact that zebra mussels can have on aquatic ecosystems.

One point can be earned for naming an impact, and 1 point can be earned for an appropriate explanation. The identification and explanation must be linked.

Impact on Ecosystem	Explanation
Increased water clarity/transparency	Mussels are filter feeders, removing solids from water as they feed.
Increased light penetration in water column	Remove suspended matter from water.
Increased photosynthesis/primary productivity	Results from increased water clarity.
Increased populations of other species (certain fish, waterfowl, etc.)	Results either from greater primary productivity (base of trophic pyramid) or greater ability of fish that are visual feeders to see their prey.
Competition from zebra mussels for available resources	Decreased populations of other species (mollusks, insects, etc.).
Decreased populations of other species (mollusks, insects, etc.)	Competition from zebra mussels for available resources.
Altered water chemistry	Mussels change biogeochemistry through filtering and digestion of food; shells sequester/store minerals.
Disrupts food chains/trophic dynamics	Eats food required by other species.

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Question 3 (continued)

(d) Identify another invasive species, either terrestrial or aquatic, and describe one negative impact it has had.

One point can be earned for naming a species, and 1 additional point can be earned for an appropriate explanation of its impact. The identification and explanation must be linked.

Acceptable examples include:

Invasive Species	Negative Impact
Cane toad	Toxin kills native predators.
Rats	Eat bird's eggs; spread disease.
Purple loosestrife	Crowds out native plant species in wetlands.
(Eurasian) water milfoil	Crowds out native plants, clogs waterways.
Snakehead fish	Preys on native fish, reducing populations.
Rabbits	Clear vegetation.
Kudzu vine	Smothers other vegetation.
Emerald ash borer	Burrowing and feeding kill trees.
Sea lamprey	Predation harms other fish.
Nutria	Eats marsh vegetation, destroying wetlands.
(Brazilian) pepper tree	Tissues are toxic; shades out other plants.
Pythons, constrictors	Eat native species, lowering populations.
Japanese/Asian beetles	Eat native plant species.
Pigeon/rock dove	Nuisance in cities; vectors of disease.
(European) starlings	Compete with native birds for nest sites.
Feral domestic animals (e.g., boar, cat)	Predators of native species.
Ice plant	Competes with native plant species.
Africanized ("killer") bees	Attacks people/animals; displaces honeybees.
Boll weevil	Important crop pest.

Note: A correct response must identify a specific organism. General categories of biota (e.g., "snakes") are not acceptable.

Question 3 (continued)

(e) One strategy for controlling an invasive species has been to introduce another nonnative species to control it; this strategy can often have unintended results. Give a specific example of the use of this strategy and discuss a negative impact of introducing a nonnative species to control an invasive species.

One point can be earned for identifying a specific example of biological control, and 1 additional point can be earned for an appropriate explanation of a potential negative impact. The two responses need not be linked.

Acceptable examples include:

Biological Control
• Insects (stem borers, leaf eaters) to feed on purple loosestrife
• Ladybird beetles (ladybugs) to feed on pest insects
• Parasitoid wasps to control weevils
• Bacteria (e.g., Bt) or viruses to control animal pests
• Mongoose to hunt rats
• Cane toads to prey on insect pests

Negative Impact
• Predation of nontarget species
• Competition with native species
• Toxic to native predators, or reduces available food to native predators
• Alters ecological interactions, e.g., food webs or biogeochemical cycles

Note: The "specific example" cannot be hypothetical or a general prescription, e.g., "introduce a predator of agricultural pests."

Question 3 (continued)

(f) Discuss TWO specific characteristics of invasive species that enable them to thrive in new environments.

Two points can be awarded: 1 point for each specific characteristic.

- Generalist species
- Excellent dispersal mechanisms, allowing it to spread
- R-selected or r-strategist

OR any of the following characteristics:

  - Large clutch size/many offspring produced
  - Early onset of reproduction/early maturation
  - Frequent reproduction

- Superior defenses against predators in new environment
- Superior skills as a predator in new environment

Note: Listed characteristics must be specific. Generic qualities or life-history strategies are not acceptable.

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Question 4

(a) Based on the rate cited above, calculate the expected increase in sea level, in meters, during the next 50 years.

One point can be earned for the correct setup, and 1 point can be earned for the correct answer.

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} = 150 \text{ mm} = 0.15 \text{ m}$$

OR

$$\frac{3.0 \text{ mm}}{\text{yr}} \times 50 \text{ yrs} \times \frac{1 \text{ m}}{1{,}000 \text{ mm}} = 0.15 \text{ m}$$

(b) Identify TWO phenomena that result from an increase in global mean atmospheric temperature and that contribute to increases in sea level. For each phenomenon that you identify, explain how it causes sea level to increase.

One point can be earned for each identification, and 1 point can be earned for each explanation. Only the first two answers will be considered.

Phenomenon	Explanation
Melting of glaciers, continental ice caps (*"Ice caps" or "polar ice caps" are NOT acceptable answers by themselves.*)	As ice melts, the amount of water in the ocean increases.
Melting of ice sheets (Greenland and Antarctica)	As ice melts, the amount of water in the ocean increases.
Thermal expansion of the ocean	As water warms, water molecules move farther apart and the volume of the ocean increases.
Melting of Antarctic ice shelves	Ice shelves are attached to continental ice and do not displace liquid water; if they break off, they will displace water and raise sea level.

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Question 4 (continued)

(c) Describe TWO environmental impacts that increasing sea level will have on an estuarine ecosystem such as those in the Mississippi Delta, Chesapeake Bay, and San Francisco Bay.

One point can be earned for each description of an environmental impact. Only the first two impacts are considered.

Impact	Description
Loss/flooding/erosion of estuary habitat (conversion to open water)	• Loss of wetlands, marshes, salt marshes, intertidal zone, riparian zone, mangroves. • May lead to changes in water depth, light levels and temperature, causing migration or local extinction of species that have specific requirements. • Inland migration of wetlands. • May lead to loss of species (fish, shellfish, birds) that rely on estuary as a nursery/breeding area.***** • May lead to loss of species that rely on estuary for protection from predators. • May lead to loss of migratory species (birds) that rely on estuary as a stopover.
Increased nutrient loads in the water	Estuaries filter out excess nutrients; without them, eutrophication may lead to algal blooms.
Increased storm destruction of areas adjacent to the estuary	• Estuaries absorb excess water, reducing flooding. • Estuaries provide a physical barrier that protects the area from storm surges, preventing erosion. • Increased erosion of coastline leads to habitat loss.
Change in salinity	• Salinity may increase. • May lead to loss of species that have a small salinity-tolerance range.
Waterlogged soils due to flooding	Loss of marsh plant species.

***Student response should show understanding of estuarine ecosystem.*

Question 4 (continued)

Impact	Description
Spreading of oil spills that occur in ocean to inland areas	• Oil may coat birds' feathers, reducing insulation and ability to fly. • Oil may coat mammals' coats; animals may ingest the oil during cleaning and die. • Oil may cause suffocation (organisms unable to perform gas exchange).

(d) Although sea level has been rising for over a century, human populations in coastal areas have increased dramatically during this period.

(i) Describe one negative economic impact that an increase in sea level will have on people who live along a coastline.

One point can be earned: only the first negative economic impact stated will be considered.

Impact	Description
Damage to private property	• Cost of replacement, relocation, or improved construction to reduce storm damage. • Increased insurance premiums. • Decrease in property values (unable to sell).
Loss of income/livelihood	• Loss of commercial fishing. • Loss of income-producing agricultural lands. • Loss of tourism dollars.
Loss of food supply	People who rely on fishing or agriculture in coastal areas will need to buy food.
Saltwater intrusion	Water supplies for drinking and irrigation may require expensive desalination treatment.

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Question 4 (continued)

(ii) Describe TWO viable strategies that governments could use to discourage people from moving to coastal areas.

One point can be earned for each description; only the first two strategies will be considered.

- Raise premiums or refuse to insure in areas that repeatedly flood/are damaged by storms
- Raise property taxes in coastal areas
- Education campaigns, PSAs, advertising that discourage movement to the coast or encourage movement away from the coast
- Offer incentives to relocate inland, such as jobs, schools, reduced property taxes
- Designate the area as a preserve/reserve making it illegal to build
- Impose stricter penalties for infringements of regulations designed to protect the coastline
- Zone to restrict building in coastal areas, limit distance to coast
- Designate the beach as public property
- Remove or ban human structures designed to stabilize shoreline (seawalls, bulkheads)
- Ban the practice of beach nourishment
- Pass rolling easements in which property owners agree to abandon buildings when their properties become flooded
- Impose a tax to support beach-area protection
- Prevent the building of infrastructure/services (roads, power lines, water lines) that service coastal areas