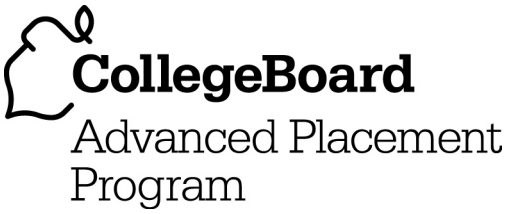

AP® Environmental Science
2004 Scoring Guidelines

AP® ENVIRONMENTAL SCIENCE
2004 SCORING GUIDELINES

Question 1

(a) On the basis of the article above, indicate one human activity that releases mercury into the environment. Describe how mercury is transported from that source and enters aquatic systems, often hundreds of miles away.

(3 points maximum out of a possible 4)

1 point for naming "the burning of coal" as the human activity that releases mercury into the environment, as mentioned in the document.

- Only the first type of fossil fuel indicated in the answer will be considered. If the wrong source is named (e.g., petroleum products) students will not earn any points in part (a).
- "Fossil fuel" alone, while not wrong, is unacceptable because mercury is a contaminant primarily in coal, and the document directs the student's attention to it.
- If students use "power plants/industry," they must indicate that coal is used.

1 point for describing how mercury is transported.

- Answers related to air transport should indicate the movement of air, wind, or air currents, since "goes into the air" does not include the idea of "transport."
- A reference to incorporation of the atmospheric mercury into the water cycle may be used to earn this point, but cannot be counted as the "aquatic systems entry" point without further elaboration.
- A student who uses "coal washing" at the power plant as the actual source of mercury pollution must describe how the water is transported from that site.

1 point for describing how mercury enters aquatic systems from the source described above.

"Aquatic systems" can include the abiotic and/or the biotic components of the system. If students discuss soil as an entry point, they must explain how mercury gets from soil to water (e.g., by erosion or leaching). Examples of acceptable answers are:

- falls as dry particles into water or onto soil
- falls with rain/precipitation into water or onto soil
- enters water and becomes incorporated into food chains
- could enter groundwater/surface water from the coal-washing process
- could enter streams and rivers from groundwater

1 possible elaboration point for an answer that indicates an unusual depth of knowledge about the subject, by making points such as:

- three states of mercury—particulate, elemental, and an oxidized form
- microorganisms in the soil and water can convert inorganic mercury into an organic form, methyl mercury, in which form it can readily enter food chains

Question 1 (cont'd.)

(b) Describe TWO ways that the amount of mercury released into the environment from the source in part (a) could be reduced.

(2 points maximum)

Note: If a student mentions "coal" in both parts of this answer, and if no specific "fossil fuel" was given in part (a) above, the student may earn the point for "the burning of coal" in part (a) if the answer is otherwise satisfactory.

1 point each for describing two of the methods given below.

- Only the first two answers will be considered.
- Simply naming a method is not enough; the answer should describe how this would result in a decrease in mercury by providing concrete examples, developing a rationale, or describing a process.
- Only one point will be earned for multiple examples of the same argument, e.g. solar and wind energy as alternatives to coal.

Reduce the amount or change the type of fossil fuel burned

- burn higher-rank coals but with equivalent (or lower) mercury content, thereby generating more BTUs per unit amount of coal
- burn coal with equivalent or better rank, but with lower mercury levels
- use another kind of fossil fuel with lower mercury content, such as natural gas
- switch to a power-generating system (wind, solar, hydroelectric, etc.) that has a much lower or non-existent mercury contamination component
- make furnaces burn more efficiently (any of a variety of methods)

Pre-combustion removal of mercury:

- wash the coal (physical density separation or chemical cleaning)

Post-combustion removal of mercury

- use sorbents such as activated carbon, calcium, sodium tetrasulfide, or silicates which convert the gaseous mercury into an insoluble, thermally stable solid compound that can then be removed by using electrostatic precipitation, wet scrubbers, baghouse, fabric filter, or other particulate removal device (gaseous mercury must be converted before any of these other control methods can be effective, so "scrubbing" or "filtering" alone is not enough)
- use catalyst systems that oxidize elemental mercury, which can then be removed, by wet lime or limestone flue gas desulfurization (FGD) systems
- cool the flue gas and capture fly ash

Question 1 (cont'd.)

Other

- enforce the Clean Air Act, stop exempting utilities from mercury control regulations, obtain international agreements, enact legislation to require controls, or the like (must include discussion of any of these chosen)
- use tax incentives or other means of encouraging voluntary reductions (must include discussion)
- conserve energy, reduce consumer demand, or the like (must include discussion)

(c) Explain why there are greater health risks associated with eating large predatory fish, such as tuna and sea bass, than from eating small nonpredatory fish.

(3 points maximum)

1 point for discussing why there would be more mercury in predatory vs. nonpredatory fish.

This explanation should be based on the idea of bioaccumulation/biomagnification and may include concepts such as:

- food chains or webs/trophic levels
- mercury transfers to higher trophic levels
- the concentration of mercury increases in higher trophic levels

1 point may be earned for discussing the relationship of size, long lifespan, and the accumulation of mercury.

For example: over the course of a lifetime, older fish have had more time to accumulate significant amounts of mercury, regardless of their trophic level.

This point also could be earned for a discussion of absorption through the skin/gills as it is related to the accumulation of mercury over a longer lifetime.

1 elaboration point is possible for an in-depth explanation of bioaccumulation/ biomagnification, or for a good explanation of one or more of the following topics:

- mercury is stored in fat/muscle and cannot be removed easily by body enzymes
- mercury can enter food chains by being converted to methyl mercury [no credit earned here if already earned in part (a)]
- explains the difference between bioaccumulation and biomagnification

Question 1 (cont'd.)

(d) Identify a toxic metal other than mercury that has a negative impact on human health and describe how it is introduced into the environment. Describe an acute sublethal effect on humans that results from exposure to this metal.

(3 points maximum) Consider only the first metal and the first effect given.

1 point for naming a toxic metal, 1 point for describing how it is introduced into the environment, and 1 point for describing a sublethal effect on humans. If no toxic metal was identified, no points could be earned in this part. (Lead was the most common answer given; following is the rubric used for lead. Many other metals could be used to earn credit in this part.)

How Lead Is Introduced (read all for a correct answer)	Effects of Lead on Human Health
Industry: mining and refining processes **Consumer goods:** batteries cigarette smoke coal combustion colored inks cosmetics electronics firing ranges/bullets food (esp. candy) gasoline additives hair dyes insecticides paint pottery glazes plumbing radiator repair shops TV picture tube toothpaste volcanic eruptions window blinds wine	abdominal pain adrenal/liver/kidney dysfunction allergies anxiety autism birth defects/toxic to the fetus blindness bones/joint pain and weakness/arthritis cardiovascular disease colic constipation convulsions depression dizziness/headache/fatigue/nausea dyslexia epilepsy GI symptoms gout hallucination/mood swings/nightmares/poor concentration/psychosis hyperactivity immune system depression impotence

Question 1 (cont'd.)

Effects of Lead on Human Health (cont'd.)
menstrual problems multiple sclerosis muscular dystrophy neurological effects/brain development and function/ hostility/hypertension/learning disorders/mental retardation/numbness Parkinson's disease prostate enlargement red blood cell/anemia/enzyme function restlessness stroke

Question 2

(a) Assuming that the existing power plant can operate at full capacity for 8,000 hours/yr, how many kWh of electrical energy can be produced by the plant in a year?

(2 points)

1 point for correct setup.
1 point for correctly calculating the amount of electricity generated per year.

Answer must show calculations.
Student must correctly convert MW to kW.
Points may be earned if the student writes the answer as a word problem.
No points earned without showing or clearly stating calculations.
Solutions to the question that use alternate setups and arrive at a correct answer will also earn points.

$12\ \text{MW} = 12{,}000\ \text{kW}$ or $1.2 \times 10^4\ \text{kW}$,

$12{,}000\ \text{kW} \times 8{,}000\ \text{hours/yr} = 96{,}000{,}000\ \text{kWh/year}$ or $9.6 \times 10^7\ \text{kWh/year}$

OR

$12\ \text{MW} \times 1{,}000\ \text{kW/MW} \times 8{,}000\ \text{hrs/yr} = 96{,}000{,}000\ \text{kWh/yr}$

$= 9.6 \times 10^7\ \text{kWh/yr}$

(b) At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year?

(2 points)

1 point for correct setup.
1 point for correct calculation.

Answer must show calculations.
Point may be earned if the student writes the answer as a word problem.
No points earned without showing or clearly stating calculations.
Solutions to the question that use alternate setups and arrive at a correct answer will also earn points.

$3{,}000\ \text{homes} \times (8{,}000\ \text{kWh/home})/\text{year} = 24{,}000{,}000\ \text{kWh/year}$

$= 2.4 \times 10^7\ \text{kWh/year}$

Question 2 (cont'd.)

(c) Compare your answers in (a) and (b) and explain why you would or would not expect the numbers to be the same.

(2 points, plus one possible elaboration point)

1 point for comparing answers (a) and (b) **with** an explanation of why the numbers in parts (a) and (b) would be the same or different (must be a viable reason)

OR

1 point for a good explanation of why (a) and (b) are different even if the calculations were not attempted.

1 possible elaboration point for explanations that go into great detail on why the numbers differ.

Possible acceptable explanations as to why the electrical output of the power plant and the community's consumption are different:

- The plant must be able to supply power during peak demand periods, not just supply power for the average energy use of the community
- The power company must plan to provide power for future growth of the community
- The plant does not run at full capacity 24 hours a day
- Consumption is less/more during different times of day/week/month/year
- Loss of energy during transmission (line loss) from plant to consumer
- The plant supplies energy to businesses and industry, not just homes
- The plant exports some of its power to the grid for use elsewhere
- Households may be using alternative energy sources (solar, etc.), and may be returning unused energy to the grid
- If a student says (a) is less than (b) with a viable reason for the difference (e.g., community uses other energy providers), points will be earned

Note: If students say that (a) and (b) are the same, they must state that this can only occur if the households have backup systems that will produce energy for them if they exceed the power generated by the plant.

Question 2 (cont'd.)

(d) Assuming that the electrical energy needs of the community do not change during the 25-year lifetime of the wind turbines, what would be the cost to the community of the electricity supplied by the WFWP over 25 years? Express your answer in dollars/kWh.

(2 points)

1 point for correct setup.
1 point for correct answer with calculations.
Solutions to the question that use alternate setups and arrive at a correct answer will also earn points.

If a student's answer in part (b) is incorrect but the student appropriately uses it as the basis for the calculations for answering the question in part (d), the student will receive full credit for answering part (d) if the setup and calculations are correct, even if the answer is not one of the ones listed below.

Solution A: Based on current community consumption of 2.4×10^7 kWh/year [from part (b)]

kilowatt-hours for 25 years $= 2.4 \times 10^7$ kWh/year $\times$ 25 years $= 6 \times 10^8$ kWh

direct cost for 25 years $=$ 10 turbines $\times$ ($\$3 \times 10^6$/turbine) $= \$3 \times 10^7$

$$\text{cost/kWh} = \frac{\$3 \times 10^7}{6 \times 10^8 \text{ kWh}} = \$0.05/\text{kWh}$$

Solution B: Based on power being generated at full capacity (students may use either the rounded value of 8,000 hours/year or the more accurate 8,760 hours/year)

8,000 hours/year $\times$ 12 MW $=$ 96,000 MWh/yr

96,000 MWh/yr $\times$ 1,000 kW/MW $=$ 96,000,000 kWh/yr

96,000,000 kWh/yr $\times$ 25 years $=$ 2,400,000,000 kWh $= 2.4 \times 10^9$ kWh

$$\text{cost/kWh} = \frac{\$3 \times 10^7}{2.4 \times 10^9 \text{ kWh}} = \$0.01/\text{kWh}$$

Note: Only one point earned for solution B, because it assumes the plants work at maximum output. The question asked for cost based on community consumption.

Question 2 (cont'd.)

(e) Identify and explain TWO environmental benefits to West Fremont of switching from coal to wind power and TWO environmental costs to West Fremont of switching from coal to wind power.

(4 points)

1 point for identifying each environmental benefit and a suitable explanation **linked** to the benefit. Benefits and costs must be *environmental* and not *economic* (e.g., agriculture). Only the first **two** benefits and explanations will be graded.

Acceptable benefits with explanation for switching to wind power include:

ENVIRONMENTAL BENEFIT	EXPLANATION
Perpetual/renewable resource	If connected to a specific environmental benefit
Reduce SO_2 , SO_3 , or SO_x emissions	Reduce acid deposition
Reduce CO_2 emissions Reduce CO emissions	Slow global warming/global climate change Must link increased CO_2 as cause

ENVIRONMENTAL BENEFIT	EXPLANATION
Reduce dust and airborne particulate matter	Reduce a specific health risk
Reduce NO_x	Reduce photochemical smog; ground-level ozone and associated health risks
Multiple use of land	If connected to an environmental benefit
Reduce thermal pollution from coolant waters of coal-burning power plant	Thermal shock; decreased dissolved oxygen content of water
Eliminate/reduce Hg, Pb, Cd, radioactivity	Reduce a specific health risk
Reduce acid mine drainage from coal mines	pH change in aquatic habitats
Reduce the need for coal mining	Reduce adverse effects of mining – mine drainage, erosion, etc.

Question 2 (cont'd.)

1 point for identifying each environmental cost and a suitable explanation **linked to** the cost. Only the first two costs and explanations will be graded. Costs must be *environmental* and not *economic* (e.g., agriculture)

Possible acceptable costs with explanation for switching to wind power include:

ENVIRONMENTAL COST	EXPLANATION
Negative aesthetic effect	Impairs view of natural landscape
Harmful to birds/migration	Birds die when they fly into spinning blades
Land requirement/alterations for wind farms	Such as: cutting down trees to construct turbines leads to increased soil erosion
Winds are not always steady	Require a backup generation system that may cause air pollution
Noise pollution from spinning blades and/or generator	Negatively impacts animal behavior
Ecosystem fragmentation	Reduction in species population

Question 3

(a) Explain how the properties of low-level radioactive waste differ from those of high-level radioactive waste and how these properties lead to different storage requirements. For one of the two types of radioactive waste, give an example of a specific isotope that may be present in the waste, and explain how human activity generates the waste.

(3 points)

1 point for correctly explaining how the properties of low-level radioactive waste differ from those of high-level radioactive waste.

DIFFERENCES IN WASTE PROPERTIES	
LOW-LEVEL WASTE	HIGH-LEVEL WASTE
Low amount of radioactivity	High amount of radioactivity
Remains dangerous for a relatively short period; has short half-life (a few hundred years or less)	Remains dangerous for a relatively long period; has long half-life (tens of thousands of years)

Note: The federal government's definitions of radioactive waste materials sometimes differ from those provided in textbooks. Answers that were correct based on the information from textbooks earned points even if they were not in line with the information in official government documents.

1 point for correctly explaining how these properties lead to different storage requirements.

DIFFERENCES IN STORAGE REQUIREMENTS		
	LOW-LEVEL WASTE	HIGH-LEVEL WASTE
PLACE OF STORAGE	On-site, either until it has decayed away and can be disposed of as ordinary trash, or until amounts are large enough for shipment to a hazardous waste landfill	On-site until shipment to an isolated area where there is minimal possibility they can contaminate the environment is possible
DURATION OF STORAGE	Safe storage will be necessary for a relatively short period (few hundred years at the most)	Safe storage will be necessary for a relatively long period (tens of thousands of years at the least)
METHOD OF STORAGE	Stored in barrels (may be shielded as necessary)	Must be stored in specially shielded containers (casks) at the site or in water pools Must be cooled before long-term storage

Question 3 (cont'd.)

1 point for providing an accurate example of a specific isotope that may be present in either low-level or high-level radioactive waste and explaining how human activity generates the waste.

SPECIFIC ISOTOPES (for isotopes in **bold**, student may indicate use in medical applications):

Americium (-241, -242), Barium-140, Bismuth (-210, -214), Carbon-14, Cerium (-141, -144), Cesium (-135, -137), Curium (-242, -243, -244), Krypton-85, Iodine (-129, **-131***), Krypton-85, Lead (-206, -210, -214), **Molybdenum-99***, Neodymium-147, Neptunium-237, Niobium-95, Plutonium (-239, -240, -241), Polonium (-210, -214, -218), Praseodymium-143, Promethium-147, Protactinium-234, Radium-226, Radon (-222, -226), Ruthenium (-103, -106),Strontium (**-89***, -90), **Technetium-99***, Thorium (-230, -234), Tritium, Uranium (-234, -235, -238), **Xenon-133***, Yttrium-91, Zirconium-95

HUMAN ACTIVITIES THAT GENERATE THE WASTE:

- Use of nuclear reactors
- Nuclear fuel fabrication
- Uranium fuel conversion facilities
- Research or treatment at hospitals, medical schools, universities, radiochemical, or radiopharmaceutical facilities
- Uranium mining
- Weapons manufacturing

(b) The United States Department of Energy recently chose Yucca Mountain in Nevada as the site for the deep underground burial of high-level radioactive waste. Describe THREE characteristics of an ideal deep underground storage site for high-level radioactive waste.

(3 points)

1 point each for describing three characteristics of an ideal deep underground storage site for high-level radioactive waste. Only the first three characteristics provided are considered.

ACCEPTABLE CHARACTERISTICS:

- Sufficiently large to accept current and future volume of waste
- Not near fault lines
- Not near volcanos
- Geological formations that are chemically nonreactive
- Remote location far from human settlements
- Provides natural defense from attack
- At least 600 meters (2,000 feet) below the surface
- Geological and/or geographical characteristics that limit contact with either surface or ground water
- Dry climate to minimize precipitation and percolation
- Close proximity to radioactive waste producers to minimize need to transport waste

Question 3 (cont'd.)

(c) Identify TWO other options that have been suggested for the long-term management of radioactive waste. Discuss the feasibility of each method.

(3 points)

1 point for identifying two additional options for the long-term management of radioactive waste. Only the first two options provided are considered.
1 point *each* for the discussion of the feasibility of the two identified options. The student must discuss the feasibility of only the identified options to earn the point.

OPTION	FEASIBILITY
Storage under Antarctic or Greenland ice sheets	Limited by technology; or threat of instability due to melting ice; or laws and international treaties
Rocket to space or Sun	Limited by cost; or danger of accident during launch or flight; or ethics; or unknown consequences
Store on the Moon	Limited by cost; or danger of accident during launch or flight; or threat of contamination of the Moon
Deep sea/ocean floor storage	Limited by danger of leaking containers; or laws and international treaties
Dump into subduction zones	Limited by facts that wastes could be spread by future volcanic eruptions; or containers may leak and contaminate ocean before being subducted; or retrieval would be impossible if method failed
Above ground storage buildings (must indicate strength and durability)	Limited by need to have adequate security or transportation concerns. They are easier to monitor.
Change it into harmless or less harmful isotopes (bio-/phytoremediation)	Limited by scientific capability
Decommissioning/entombing old plants	Limited by leaks; or threats to security; or stability of the site
Ship to other countries	Limited by ethics; or threat of terrorism; or laws and international treaties; or transportation concerns; or doesn't solve the problem
Reduce energy demands/use alternate energy	Limited by the public's willingness to do so; or growing populations; or monetary disincentives

Question 3 (cont'd.)

Reduce the amount of nuclear fuel needed	Limited by technology
Reprocess spent fuel	Limited by U.S law, the NWPA, 1982; or the NIMBY syndrome. Currently used in France and Japan.
Reduce nuclear weapons manufacture	Limited by national security concerns; or jobs; or already a surplus
Use cyclotron	Already in use
Non-radiative alternatives	Already in use
Ocean dumping	Limited by law in U.S. Currently used by England and Pakistan.

(d) Exposure to high levels of ionizing radiation has adverse effects on human health and can result in immediate death. Identify one sublethal adverse effect on human health that can result from exposure to ionizing radiation, and explain how this effect is caused by the radiation.

(1 point)

1 point for correctly identifying a sublethal adverse effect on human health *and* explaining how the effect is caused by the radiation.

SUBLETHAL ADVERSE EFFECTS:

- Cancer/tumors
- Brain damage or delirium or convulsions
- Eye damage or cataracts
- Gastrointestinal tract damage or nausea and vomiting
- Damage to fetus
- Damage to ovaries and testes or sterility or birth defects
- Damage to bone marrow
- Impairment of immune system
- Blood vessel damage or bruising from internal bleeding
- Burns
- Hair loss (student must connect hair loss to cell/follicle damage)

CAUSES:

- Cell/tissue damage
- Cell death
- DNA/chromosomal damage

Question 4

(a) Identify and describe one chemical soil test and one physical soil test that could be performed and explain how the results of these tests will allow the cooperative extension service to make specific recommendations for sustainable agriculture.

(3 points)

1 point for identifying and describing a chemical soil test.

CHEMICAL TESTS:

- pH -- Measures the acidity or alkalinity or hydrogen ion concentration
- Salinity (salinization) -- Measures salt content of soil
- Organic content (humus) -- Analysis that indicates organic content
- Ion exchange capacity -- Measures ability to absorb and release cations, especially plant nutrients

On the following chemical tests the name is a sufficient descriptor of the test. (Symbols for the elements are acceptable.)

- ♦ Major elements
- ♦ Measures the amount of nitrogen, phosphorus, potassium, or sulfur in any form
- ♦ Trace elements
- ♦ Measures the amount of iron, cobalt, boron, calcium, magnesium, manganese, selenium, aluminum, mercury, etc.

1 point for identifying and describing a physical soil test.

PHYSICAL TESTS (A description of how the test is conducted is sufficient for identification of the test):

Soil Texture Ribbon test (ped test) Soil sieve test (nested sieves) Composition/make-up Sedimentation Hydrometer method Particle-size analysis	Percent/proportion of sand, silt, and clay-sized particles that make up the solid inorganic phase of soil
Water-holding capacity Porosity	Amount of water the soil can hold due to amount of pore or air space
Moisture content	Amount of water in the soil at a given time
Particle density or bulk density	How much a particular soil weighs per unit volume
Soil Structure (friability) Colloids and aggregates	How soil is held together forming small clumps of various types

Question 4 (cont'd.)

PHYSICAL TESTS (continued):

Percolation rate Soil drainage Infiltration Permeability	Speed of infiltration of water into soil
Capillarity of soil	Movement of water against the pull of gravity
Soil compaction	Degree to which soil resists pressure from wind, water, and machinery
Soil profile analysis	Determines the nature of the soil horizons (structure, depth, color – does not indicate texture)
Color	Indicates soil components or properties (e.g., iron, amount of humus, level of water table)

1 point for making specific recommendations for sustainable agriculture for either a physical or a chemical test.

APPLICATION OF TEST RESULTS TO SUSTAINABLE AGRICULTURE FROM COOPERATIVE EXTENSION SERVICE (must relate to one of the previous tests):

- Indicating suitable crops and cultivation practices
- Adding soil additives such as sand, clay, or humus to affect ion-exchange capacity as well as moisture content and water-holding capacity
- Applying lime for acid soil; applying sulfur for alkaline (basic) soil to neutralize
- Planting leguminous crops to increase nitrogen, or apply manure
- Liming or applying bone meal to improve phosphorus
- Burning crop residue to increase potassium
- Examining irrigation practices to combat salinity, erosion, and excessive water usage
- Adding lime or limestone to increase calcium and magnesium
- Applying gypsum or green sand to increase the sulfur content and water-holding capacity
- Adding organic matter (animal manure, green manure, or crop residues) to improve many of the soil's physical and chemical properties
- Increasing soil fertility by using other practices such as grassed waterways and no-till crop rotation
- Reducing the use of inorganic fertilizers
- Decreasing agricultural soil erosion by using Best Management Practices (BMP)

Question 4 (cont'd.)

(b) Explain one advantage and one disadvantage to using inorganic commercial fertilizers.

(2 points)

1 point for advantage
1 point for disadvantage

ADVANTAGES	DISADVANTAGES
Easily obtained, transported, stored, and applied	Adds no humus or organic matter to soil/decreases water- holding capacity
If both have to be purchased, they are more economical than organic fertilizers	Lowers oxygen content of soil and keeps nutrients from being taken up as efficiently
Nutrients are concentrated and only small amounts must be applied	Does not completely supply all micronutrients
Computerized applications can release specific minerals needed by plants	Requires large amounts of energy for production, transportation, and application
Nutrients are immediately available to the crop	Releases nitrous oxide (N_2O) a greenhouse gas
Increase soil fertility	Over-application may harm plant
Have guaranteed/specific nutrient analysis	Aquatic pollution resulting from runoff in surface or groundwater is detrimental to humans or ecosystems
Increases crop yield	Can be very expensive to obtain and apply as compared to unpurchased organic fertilizer (if this is available)
Speeds up the growing process	

(c) Describe two soil conservation practices that are designed to decrease soil erosion.

(2 points)

1 point each for identification of agricultural conservation practice and explanation of how it decreases soil erosion (practice must be linked to how it decreases erosion). If student describes three or more practices, only the first two will be scored.

Question 4 (cont'd.)

PRACTICE	HOW IT DECREASES EROSION
Conservation tillage	Disturb the soil as little as possible when planting crops
No-till	Inject seeds into slits or holes in the soil by machine – minimum soil disturbance
Minimum tillage/reduced tillage	Decrease the number of times the soil is disturbed – maintains crop residue
Terracing or division terrace	Shape land to create level shelves of earth to decrease soil and water runoff

PRACTICE	HOW IT DECREASES EROSION
Contour farming or planting	Plow in rows with the contour of gently sloped land to slow water runoff
Strip cropping/intercropping/polyculture	Plant different crops in alternating strips to reduce water runoff and wind erosion
Alley cropping /agroforestry	Plant crops in strips between trees and shrubs to reduce wind and water erosion
Windbreaks or shelterbelts of trees	Reduce wind erosion
Rotation of crops with a ground cover	Plant back-to-back (multicropping) to prevent erosion
Grassed waterways	Decreases gully erosion
Plant cover crops/native grasses	Prevents erosion when main crops cannot be planted
Protect riparian zones (buffer strips)	Prevents soil erosion into rivers and streams
Mulching	Prevents raindrop impact and runoff
Land leveling	Recontour land in order to prevent soil loss
Leave land fallow with cover crop	Leave land undisturbed or ungrazed for a period of time
Gully reclamation (arroyo)	Reclaim steep slopes from gully erosion
Modified irrigation methods	Decreases water's ability to act as an erosion agent (run-off)
Sustainable grazing	Regulates stocking rates to sustain cover
Land Classification (NRCS; SCS)	Decreases utilization of easily erodible marginal land

Question 4 (cont'd.)

(d) Identify one biome that is characterized by soil that is rich in humus. Describe how humus originated in the soils of this biome, and TWO ways that humus improves soil conditions for plant growth.

(4 points, maximum 3 points for this part)

1 point for correctly naming biome.
1 point for explaining how the humus originated in that biome.
2 points for explaining how humus improves soil conditions (1 point for each explanation).

BIOME	HOW HUMUS ORIGINATED
Deciduous forest: • tropical/seasonal (not tropical rainforest) • temperate	Plant and animal materials decompose
Grasslands (temperate and tropical) • prairie • savannah • steppes • pampas	Grasses form a large amount of organic matter that decomposes
Temperate rainforest	Needles/leaves decompose to form a layer of humus

How humus improves soil conditions:

- Provides nutrients/fertility for plants and soil organisms
- Helps topsoil hold water (water-holding capacity)
- Makes root growth easier
- Improves soil aeration
- Improves habitats for soil organisms
- Improves buffering capacity, which stabilizes pH
- Promotes development of mycorrhizae
- Prevents erosion
- Improves soil structure
- Improves porosity