



AP[®] Environmental Science 2014 Scoring Guidelines

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**AP[®] ENVIRONMENTAL SCIENCE
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Question 1

(a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.

(i) “Nuclear power plants produce no dangerous solid waste.”

(1 point can be earned for disagreeing along with one of the following justifications)

- Radioactive wastes are produced (must be stored for long periods of time)
- Spent fuel rods are radioactive
- Clothing, gloves, tools are radioactive
- Radioactive waste results from accidents

(Note: No point can be earned if the student states that they agree with the argument.)

(ii) “Using nuclear power plants avoids the release of greenhouse gases.”

(1 point can be earned for a correct justification of the stated position)

Position	Justification
Agree	<ul style="list-style-type: none">• Fossil fuels are not combusted• The normal operation involves no combustion
Disagree	<ul style="list-style-type: none">• GHGs are released when fossil fuels are used during the mining, transportation, enrichment processes of fuel, construction, and decommissioning of nuclear power plants• Water vapor is released

(b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. Describe TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).

(2 points: 1 point for each correct description. Only the first two descriptions can earn a point)

- Habitat or riparian area destruction/fragmentation at the construction site
- Disruption of habitat caused by the installation of power lines
- Water pollution/stormwater runoff
- Soil compaction from the construction process or by machinery use
- Sediment runoff/erosion in wet weather
- Noise pollution from machinery
- Construction waste disposal/landfill
- Gases/pollution emitted from machinery such as CO₂, NO₂, SO₂, CO, PM

(Note: Only problems relating to the construction of the power plant can earn a point.)

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2014 SCORING GUIDELINES**

Question 1 (continued)

(c) Suppose that the nuclear power plant is constructed on the Fremont River site.

(i) Identify the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant's normal daily operation.

(1 point can be earned for correctly identifying thermal pollution as the most likely pollution threat. Release of radioactive wastes is NOT part of the normal operation of a nuclear power plant)

(ii) Discuss one potential ecological consequence of the pollution threat that you identified in part (i).

(1 point can be earned for discussing an ecological consequence of thermal pollution)

- Decline in dissolved oxygen (DO)
- Impacts on biodiversity
- Thermal shock in organisms
- Increased rates of metabolism in organisms
- Increased bacterial growth
- Increased incidence of disease in fish
- Increased algal growth

(iii) Identify a system often used in nuclear power plants to reduce the pollution you identified in part (i).

(1 point can be earned for identifying an acceptable system)

- Cooling towers
- Cooling ponds and canals
- Longer discharge pipes (increase the distance between the power plant and the discharge point)

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Question 1 (continued)

(d) Describe TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.

(2 points: 1 point for each correct description of a valid step to reduce the amount of electricity being used in Fremont)

- Replace existing appliances with more efficient appliances (e.g., air conditioners, heat pumps, refrigerators, stoves, hot water heaters)
- Replace electrical appliances with gas appliances (e.g., stove, hot water heater)
- Switch to passive solar heating or cooling techniques
- Replace incandescent light bulbs with CFLs or LEDs
- Replace a conventional water heater with a tankless hot water heater
- Increase insulation (e.g., walls, ceiling, hot water heater)
- Turn thermostats down in the winter or up in the summer
- Turn off electrical appliances when not in use
- Unplug chargers
- Develop a series of public service announcements (PSAs) to educate the public about how to reduce electrical consumption
- Other appropriate techniques

(Note: points earned for reducing electrical use, not for replacing the source of the electrical power.)

(e) Identify a specific nuclear power plant at which a major accident has occurred. Explain one environmental consequence (other than effects on human health) of a nuclear power plant accident.

(2 points: 1 point for identifying a plant where a major accident has occurred and 1 point for explaining an environmental consequence of a nuclear accident)

The following are acceptable nuclear power plant accident sites:

- Three Mile Island
- Chernobyl
- Fukushima Daiichi

Correct explanations of environmental consequences due to radiation leaks include the following:

- Cancer/tumors in animals
- Radioactive contamination of plants or animals in food webs
- Genetic mutations
- Death of plants or animals
- Impacts on biodiversity
- Impacts on plant or animal population size

(Note: The explanation **does not** have to be linked to the specific accident; however, if the explanation is linked, it must be correct.)

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2014 SCORING GUIDELINES**

Question 2

Fremont Water Data
The shopping center's parking lot is 200 meters long and 100 meters wide.
Fremont has an area of 10 km ² .
Impervious surfaces cover 20 percent of Fremont's area.
The FWTP typically treats 5,000 m ³ of domestic sewage per day.
The FWTP has the capacity to treat 10,000 m ³ of combined sewage and storm water per day.

(a) Identify TWO specific pollutants in storm-water runoff that degrade the quality of surface water.

(2 points: 1 point for each bulleted pollutant)

- Nitrogen/nitrates/NO₃⁻
- Phosphorus/phosphates/PO₄³⁻
- Fertilizers
- Pesticides/herbicides
- Silt/sediment/soil
- Pathogens (two specific pathogens can each earn 1 point):
 - *E. coli*/coliform bacteria
 - *Salmonella*
 - *Cryptosporidium*
- Ammonia/nitrogenous wastes
- Animal feces
- [Road] salts
- Motor oil
- Grease
- Antifreeze
- Rubber (tire residue)
- Gasoline
- Trash (e.g., plastics, garbage, cigarette butts)
- Detergents
- Sulfuric/nitric acid from acid rain
- Mercury from contaminated rainfall

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Question 2 (continued)

- (b) Calculate the volume of water (in m³) that runs off the Shoppes at Fremont parking lot after a 5 cm rainfall event. Assume that all the water that falls on the parking lot runs off.**

(2 points: 1 point for a correct setup and 1 point for the correct answer)

$$[200 \text{ m} \times 100 \text{ m} = 20,000 \text{ m}^2 \text{ or } 2 \times 10^4 \text{ m}^2]$$

$$\left[5 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.05 \text{ m} \right]$$

$$200 \text{ m} \times 100 \text{ m} \times 0.05 \text{ m} = 1,000 \text{ m}^3 \text{ or } 1 \times 10^3 \text{ m}^3$$

(Note: Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct answer.)

- (c) Calculate the volume of storm-water runoff (in m³) generated in all of Fremont by the 5 cm rainfall event. Assume that only the impervious surfaces generate runoff.**

(2 points: 1 point for a correct setup and 1 point for the correct answer)

$$\left[5 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.05 \text{ m} \right]$$

$$\left[10 \text{ km}^2 \times \frac{1 \times 10^6 \text{ m}^2}{1 \text{ km}^2} = 10,000,000 \text{ m}^2 \text{ or } 1 \times 10^7 \text{ m}^2 \right]$$

$$0.05 \text{ m} \times 1 \times 10^7 \text{ m}^2 \times 0.20 = 100,000 \text{ m}^3 \text{ or } 1 \times 10^5 \text{ m}^3$$

OR

$$5 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 10 \text{ km}^2 \times \frac{1 \times 10^6 \text{ m}^2}{1 \text{ km}^2} \times 0.20 = 100,000 \text{ m}^3 \text{ or } 1 \times 10^5 \text{ m}^3$$

(Note: Units are not required in the answer; however, students must show the calculation in order to receive credit for the correct answer.)

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Question 2 (continued)

- (d) **Assume that all the runoff that you calculated in part (c) is captured by the storm sewers in one day. Calculate the volume of untreated water (in m³) that bypasses the plant as a result of the storm. (Note that the plant still receives 5,000 m³ of domestic sewage per day.)**

(1 point for the correct answer, with work shown)

$$100,000 \text{ m}^3 + 5,000 \text{ m}^3 - 10,000 \text{ m}^3 = 95,000 \text{ m}^3$$

OR

$$[10,000 \text{ m}^3 - 5,000 \text{ m}^3 = 5,000 \text{ m}^3]$$

$$100,000 \text{ m}^3 - 5,000 \text{ m}^3 = 95,000 \text{ m}^3$$

- (e) **Describe TWO ways that the volume of storm-water runoff can be reduced.**

(2 points: 1 point for each description of a strategy for reducing storm-water runoff)

- Decreasing area covered by impervious surfaces would increase infiltration of storm water
- Increasing area covered by trees/vegetation would increase infiltration/allow for greater uptake of storm water
- Creating basins/ponds to hold storm water
- Creating wetlands to absorb storm water
- Installing rain barrels, cisterns, or other devices to hold storm water
- Using green roofs or rooftop gardens to use rainwater
- Contour farming/terracing to allow water to infiltrate soil

- (f) **Describe one environmental problem (other than pollution from runoff and from untreated sewage) that results from having extensive paved areas.**

(1 point can be earned for a description of an environmental problem)

- Habitat destruction/biodiversity loss caused by the removal of vegetation (or other plausible description of a mechanism for habitat destruction/biodiversity loss)
- Habitat fragmentation caused by roads dividing habitat into smaller areas
- Microclimate caused by paved surfaces absorbing heat/solar energy and releasing heat [at night]
- Flooding/bank erosion/turbidity/loss of aquatic organisms caused by excessive runoff into surface waters
- Groundwater depletion because water runs off rather than infiltrating soil/recharging aquifers
- Drying of soil/subsidence/formation of sinkholes because water runs off instead of infiltrating soil
- Erosion caused by flooding/excessive runoff
- Flooding caused by excessive runoff/lack of infiltration of storm water

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Question 3

(a) Japan, Indonesia, and the Philippines are examples of volcanic island chains that have formed along subduction zones between plates in the western Pacific.

(i) Describe what happens when two tectonic plates collide along a subduction zone.

(1 point for a correct description of plate movement in a subduction zone)

- One plate is pushed beneath the other, or equivalent description
- A trench may be formed at the subduction zone

(ii) Explain how subduction leads to volcanic activity.

(2 points: 1 point for a correct explanation of one plate being pushed down and melted and 1 point for a correct explanation of molten material/magma rising to the surface near the zone)

(b) Although the landscape following a volcanic eruption may appear unable to support ecological communities, over time the area can be transformed through succession.

(i) What is primary succession?

(1 point for a correct description of the establishment of organisms where bare rock/ash/sand/inorganic substrate, or no soil previously existed)

(ii) Explain how primary succession can lead to soil formation on a newly formed volcanic landscape.

(2 points: 1 point for a correct explanation of the role of organisms in physically/chemically weathering rock and 1 point for a correct explanation of the role of organisms and decomposition in soil formation over time)

(c) In addition to volcanic activity, highly destructive tsunamis are generated along Pacific Plate subduction zones.

(i) Explain how a tsunami is generated along a subduction zone.

(2 points: 1 point for a correct explanation of tsunami generation resulting from an underwater earthquake and 1 point for a correct explanation of rapid water displacement leading to tsunami formation)

(ii) Describe one negative ecological impact that tsunamis have on coastal environments.

(1 point for a correct description of a negative ecological impact; only the first description given can earn points)

- Destruction of/loss of habitat such as mangrove forests, coral reefs, etc.
- Flooding resulting from tsunami waves can create saltwater intrusion into coastal ecosystems
- Drowning of terrestrial species

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2014 SCORING GUIDELINES**

Question 3 (continued)

(d) Southern California experiences periodic devastating earthquakes along the San Andreas Fault, which is a transform boundary located along the eastern edge of the Pacific Plate.

(i) Describe what happens to the tectonic plates along a transform boundary at the moment when the earthquake occurs.

(1 point for a correct description of the movement of plates when an earthquake occurs)

- A large amount of energy is released
- Plates suddenly/rapidly slide past each other in opposite directions

(ii) Describe what happens to the tectonic plates along a transform boundary during the time between earthquakes.

(1 point for a correct description of tectonic plates along transform faults binding or locking-up causing pressure to build up over time)

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2014 SCORING GUIDELINES

Question 4

(a) The atmosphere is one important carbon reservoir.

(i) Describe a biological process by which carbon is removed from the atmosphere and converted to organic molecules.

(1 point for a correct description, with or without an equation: A student can earn the point even without explicitly identifying the process as photosynthesis if an accurate description is provided. No point is earned for naming photosynthesis without a description)

Example:

Photosynthesis: the process by which plants/autotrophs take in carbon dioxide from the atmosphere and convert it into food/glucose/sugar/complex carbohydrates; plants/autotrophs fix carbon into food/glucose/sugar/complex carbohydrates.

(ii) Describe a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.

(1 point for a correct description: A student can earn the point even without explicitly identifying the process if an accurate description is provided. No point is earned for listing a word as an answer; the answer must identify the form of carbon being released into the atmosphere as part of the description)

- Respiration breaks down food/glucose/sugar/complex carbohydrates and releases CO₂ into the atmosphere
- Animals digest food and produce gases such as methane that can be emitted either through belching or flatulence
- Decomposition of organic material by bacteria or fungi converts organic carbon into gases such as methane

(b) Oceans and terrestrial systems are also important carbon reservoirs.

(i) Explain how atmospheric carbon is incorporated into two oceanic sinks.

(2 points: 1 point for each correct description of carbon incorporation into an oceanic sink. Only the first two descriptions can earn points)

- Carbon (CO₂) can be taken up by organisms like phytoplankton for photosynthesis
- Carbon can be taken up by marine organisms and used for shells, skeletons, coral, etc.
- Biological pump (organisms in the upper ocean sink to the bottom of the ocean)
- Atmospheric CO₂ can dissolve directly into ocean water **OR** atmospheric CO₂ can dissolve into precipitation and ultimately reach the ocean
- Carbon can react with other elements/compounds and form carbonates/limestone/sedimentary rocks (just “rocks” is too vague to earn a point)

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2014 SCORING GUIDELINES**

Question 4 (continued)

(ii) Identify one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.

(1 point for the correct identification of a long-term terrestrial sink of carbon)

- Old growth forests/trees that live for thousands of years (just “forests” does not earn credit)
- Trapped/incorporated into ice caps/glaciers
- Limestone or sedimentary rocks
- Incorporation into soil
- Freshwater wetlands/bogs
- Peat formation/burial of plant material under anaerobic conditions
- Dissolved in aquifers

(c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. Discuss TWO other human activities that increase the concentration of carbon in the atmosphere.

(2 points: 1 point for each accurate discussion of a human activity that increases atmospheric carbon compounds NOT related to burning fossil fuels)

- Deforestation—cutting down trees reduces the reservoirs for carbon **OR** cutting down trees can result in carbon being released back into the atmosphere through the process of decay/decomposition
- Biomass burning releases carbon (CO, CO₂, carbon particulates)
- Trash/waste incineration can release carbon (CO₂, CO, carbon particulates)
- Slash and burn agricultural practices—burning organic matter releases carbon (CO₂, CO, carbon particulates)
- Deep plowing or strip mining disrupts soil and releases carbon (CO₂)
- Humans make landfills that can produce carbon-containing carbon-based gases (mainly methane)
- Raising cows and/or other ruminant animals releases carbon-containing gases (methane)
- Manufacture and use of CFCs/HFCs/other carbon-containing compounds releases carbon
- Destruction of wetlands (releases CO₂/removes sink for CO₂)
- Production of cement releases CO₂

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2014 SCORING GUIDELINES**

Question 4 (continued)

(d) Identify an environmental problem that results from elevated atmospheric carbon concentrations. Discuss one consequence of the problem you identified.

(2 points: 1 point for identification of a specific environmental problem associated with elevated atmospheric carbon and 1 point for discussion of a consequence of the identified problem)

(Note: The discussion of a consequence must be connected to the stated environmental problem and must be connected to the environment. Examples of environmental problems and consequences are shown in the table below.)

Environmental problem	Environmental Consequence
Global climate change/global warming/increased global temperatures	<ul style="list-style-type: none"> • some species of plants and/or animals will not be able to survive temperature changes • climate zones will shift so some species may not be able to adapt • sea level rise which will flood habitats
Sea level rise	<ul style="list-style-type: none"> • coastal habitats will be flooded
Ice caps/glaciers melting	<ul style="list-style-type: none"> • flooding and habitat loss
Ocean acidification	<ul style="list-style-type: none"> • shells of marine organisms may dissolve • lower pH may be below the tolerance level of some species
Reduction in air quality due to (for example) increased CO in the atmosphere	<ul style="list-style-type: none"> • hazardous to animals breathing it in

(e) Phosphorus is another element important to all organisms.

(i) Describe one major way in which the phosphorus cycle differs from the carbon cycle.

(1 point for a correct description of a difference between the phosphorus and carbon cycles)

- Phosphorus cycle does not typically have a gas/atmospheric phase
- It is more difficult for living organisms to access phosphorus since it has to be weathered from rocks and minerals (phosphorus cycle is much “slower” than the carbon cycle; phosphorus has fewer sinks than carbon)

(ii) Identify one reason that phosphorus is necessary for organisms.

(1 point for a correct reason that phosphorus is necessary for organisms)

- Phosphorus is a component of nucleotides/ATP in cells
- It is necessary for the formation of DNA and RNA
- Phospholipids are a major component of all cell membranes
- Phosphorus is found in/gives strength to the bones and/or enamel of teeth in mammals