2022

AP® Environmental Science

Scoring Guidelines

Set 1

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram. **1 point**

Accept one of the following:

- Area A
- Site/area upstream from the factory

(ii) **Identify** the dependent variable in the study. **1 point**

- Turtle nesting success

(iii) Based on the information provided, **identify** a likely scientific question for the study. **1 point**

Accept one of the following:

- Does mercury content in the turtle's habitat affect common snapping turtle nest success?
- Does mercury content in the turtle's habitat affect the location/site of common snapping turtle nests?

(iv) **Describe** why researchers measured mercury levels in locations upstream from the factory. **1 point**

Accept one of the following:

- The upstream locations acted as a control group in the study.
- The site was used to compare with the high mercury turtle nests downstream.

(v) There are plans to remove trees and other vegetation along the riverbank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B. **1 point**

Accept one of the following:

- With more open area closer to the river, turtles don't have to travel as far to build nests, leading to exposure to higher levels of mercury near the river, decreasing the number of successful nests.
- With less vegetation to remove the mercury/heavy metals/endocrine disruptors/pesticides, there will be increased concentrations in the soil, decreasing the number of successful nests.
- Soil erosion along the stream would increase, which would make it more difficult for turtles to build nests there and decrease the number of successful nests.
- With less vegetation and reduced shade, the soil temperature will increase/moisture will decrease, decreasing the number of successful nests.

Total for part (a) 5 points

(b) (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism. **1 point**

Accept one of the following:

- The mercury/persistent pollutant could bioaccumulate in the tissues of organisms because the pollutants do not easily break down and can accumulate over time.
- Mercury is a neurotoxin, which can disrupt an animal's nervous system/neuron functioning.
- The mercury/persistent pollutant disrupts regular functioning of an animal's brain/kidneys/liver/immune system/reproductive system and can lead to death.

(ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem. **1 point**

Accept one of the following:

- A toxin can biomagnify in the food chain impacting top predators that will have a very high concentration of the pollutant.
- The death of top predators in a food chain leads to a trophic cascade.
- Reproductive success of individual organisms can decrease from exposure to the pollutant, altering the ecosystem's food webs/trophic levels and decreasing its stability/resulting in a decline in biodiversity.

(iii) Researchers measured methylmercury in a location downstream from the factory. **1 point**
Explain how methylmercury could be present in the stream.

- Mercury is likely released into the stream by the factory as a waste product. Bacteria/microorganisms in the water/sediments then convert the mercury into methylmercury.

(iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **1 point**
Explain how the pattern shown in the diagram supports or refutes this claim.

Accept one of the following:

- The nests near the river in Area B where there is mercury are not successful, but the nests further away are successful. This supports the claim that the high concentration in the soil negatively affects the nesting success.
- There are fewer total nests/successful nests in Area B closer to the river than in Area A indicating that the mercury in the soil has negatively affected the nesting success. This supports the claim.

Total for part (b) 4 points

(c)	The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area. Accept one of the following: • Tilling/plowing softens/loosens soils and/or removes organic matter or leads to erosion. • Monocropping removes nutrients and/or moisture from soil. • Use of synthetic fertilizers disrupts the soil chemistry in areas used for agriculture. • Irrigation can lead to waterlogging, erosion, and/or salinization of soils. • Slash and burn removes vegetation and upper organic layers of the soil/adds nutrients to the soil. • Use of industrialized machinery (harvesters, plows, planters) compacts soil. • Use of polycultures/cover cropping with nitrogen-fixing plants can add nutrients to soil. • Use of manure/organic fertilizer can increase moisture content of the soils.	**1 point**
	Total for part (c)	**1 point**
	Total for question 1	**10 points**

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

(a) (i) Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania. **1 point**

- 64 mg/L

(ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well. **1 point**

Accept one of the following:

- Methane concentration decreases as distance from the fracking well increases.
- Methane concentration increases as distance from the fracking well decreases.
- There is an inverse/nonlinear relationship/negative correlation between the two variables.

(iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well. **1 point**

Accept any value between:

- 1,800 – 2,200 meters

(iv) **Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process. **1 point**

Accept one of the following:

- Fracking fluid is injected/pumped into the well under high pressure, opening rock fissures, releasing oil and natural gas.
- Sand grains in the fracking fluid hold the newly formed cracks/fractures open to allow the oil and natural gas to flow up the well.

(v) **Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs. **1 point**

Accept one of the following:

- Earthquakes/seismic activity
- Ground subsidence/sinkholes

Total for part (a) **5 points**

(b) (i) The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource. **1 point**

- Tragedy of the Commons

(ii) **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions. **1 point**

Accept one of the following:

- Loss of habitat/productivity in spring-fed ecosystems as springs dry up
- Loss of habitat/productivity/degraded water quality in streams and estuaries fed by groundwater discharge
- Soil erosion as vegetation dies as a result of lowered water table and roots no longer hold soil
- Desertification as a result of lowered water table

(iii) **Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption. **1 point**

- The ocean water flows into aquifers (saltwater intrusion), contaminating the aquifer with saltwater.

Total for part (b) **3 points**

(c) (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil. **1 point**

Accept one of the following:

- Increase fuel economy standards for motor vehicles.
- Invest in renewable energy resources.
- Use tax incentives to encourage sales of hybrid/electric vehicles.
- Subsidize projects that increase the use of public transportation/walking/cycling.
- Create tax incentives for companies offering work-from-home options.
- Increase gasoline tax/reduce oil subsidies.

(ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change. **1 point**

Accept one of the following:

Governmental action proposed in (c)(i)	Justification of the action proposed by stating a potential environmental advantage
Increase fuel economy standards for motor vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations

	• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Invest in renewable energy resources	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Use tax incentives to encourage sales of hybrid/electric vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Subsidize projects that increase the use of public transportation/walking/cycling	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Create tax incentives for companies offering work-from-home options	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater

	depletion/contamination from fracking/drilling operations • Decreased oil consumption which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
Increase gasoline tax/reduce oil subsidies	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
	Total for part (c)	**2 points**
	Total for question 2	**10 points**

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

(a) **Describe** how urbanization leads to the formation of urban heat islands. **1 point**

Accept one of the following:

- Urban buildings can block wind currents, increasing local temperatures.
- Urban building materials/structures such as roads, sidewalks, and/or buildings hold in heat, causing the temperatures to increase.
- Urban areas have fewer trees, resulting in less shade/less transpiration, causing temperatures to increase.
- Urban areas have large numbers of vehicles/air conditioners/machinery that produce waste heat, causing temperatures to increase.

Total for part (a) **1 point**

(b) **(i)** **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands. **1 point**

Accept one of the following:

- Plant green roofs on buildings/plant vegetation around buildings/increase green space.
- Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces.
- Increase efficiency of a system that produces waste heat (vehicles, air conditioners).
- Decrease use of a system that produces waste heat (vehicles, air conditioners).

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands. **1 point**

Accept one of the following:

Solution proposed in (b)(i)	Justification solution with additional benefit
Plant green roofs on buildings/plant vegetation around buildings/increase green space	• Provides food crops • Creates habitat for biodiversity • Slows/captures runoff • Insulates buildings, which reduces heating/cooling costs • Provides aesthetic/cultural/recreational benefits • Reduces air pollution (particulates, O_3, SO_2, NO_2, CO) • Filters the air • Removes carbon from the atmosphere

Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces	• Reflects solar energy, which reduces cooling costs • Reduces energy consumption, which reduces cooling costs
Increase efficiency of a system that produces waste heat (vehicles, air conditioners)	• Decreased production of CO_2, which reduces climate change • Reduces energy consumption, which reduces costs
Decrease use of a system that produces waste heat (vehicles, air conditioners)	• Decreased production of CO_2, which reduces climate change • Decreased use of vehicles, which reduces air pollution • Reduces energy consumption, which reduces costs

Total for part (b) **2 points**

(c) (i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work. **1 point**

One point for the correct setup (must include multiplication by 100) to calculate the percent change:

- $\frac{44.5\% - 15.9\%}{15.9\%} \times 100$
- $\left(\frac{44.5\%}{15.9\%} - 1\right) \times 100$

One point for the correct calculation of the percent change: **1 point**

Accept one of the following:

- 179.9%
- 180%

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from $0.11 per kWh to $0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the change of electricity cost for one year:

- $12{,}900 \text{ kWh} \times \left(\frac{\$0.13 - \$0.11}{\text{kWh}}\right)$
- $12{,}900 \text{ kWh} \times \frac{\$0.13}{\text{kWh}} = \$1677$ **AND** $12{,}900 \text{ kWh} \times \frac{\$0.11}{\text{kWh}} = \$1419;\ \$1677 - \$1419$

One point for the correct calculation of the change of electricity cost for one year: **1 point**

- $258

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of kWh that can be produced at maximum output:

- $30 \text{ panels} \times \frac{300 \text{ watts}}{\text{panel}} \times \frac{1 \text{ kW}}{1{,}000 \text{ watts}} \times \frac{4 \text{ hours}}{\text{day}} \times \frac{365 \text{ days}}{1 \text{ year}}$

One point for the correct calculation of the amount of kWh that can be produced at maximum output: **1 point**

- 13,140 kWh per year

Total for part (c) **6 points**

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August. **1 point**

- During June through August, the Northern Hemisphere is tilted toward the Sun and receives more direct solar energy (per unit area) than the Southern Hemisphere.
- During June through August, the Northern Hemisphere is tilted toward the Sun and has more hours of sunlight.

Total for part (d) **1 point**

Total for question 3 **10 points**