

2023



AP[®] Environmental Science

Scoring Guidelines

Set 1

AP[®] Environmental Science 2023 Scoring Guidelines

Question 1: Design an Investigation

10 points

(a) **Identify** the control group in this experiment.

1 point

Accept one of the following:

- Plot D
- Unmodified beans

(b) **Identify** the scientific question for the investigation.

1 point

Accept one of the following:

- Will genetically modified green beans have higher crop yields than unmodified green beans?
- Is there a difference between the crop yields of genetically modified and unmodified green beans?
- Does genetically modifying green beans affect crop yield?

(c) Researchers repeated the experiment modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification.

1 point

Accept one of the following:

- With less water, there will be lower crop yield/fewer green beans harvested in all plots.
- The genetically modified beans will remain similar in yield because they are resistant to drought/need less water, but the unmodified beans will decrease in crop yield because they will receive less water.

(d) Based on the data in the table, **identify** the plot with the lowest soil temperature.

1 point

Accept one of the following:

- Plot D
- The unmodified green beans

(e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans.

1 point

Accept one of the following:

- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are lower with the genetically modified beans.
- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are higher with the unmodified beans.

- (f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted. **1 point**

Accept one of the following:

- The hypothesis is supported because there is less fertilizer (phosphorus/nitrogen) in the runoff from plot B, so the beans in plot B are absorbing/taking up more fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because there is more fertilizer (phosphorus/nitrogen) in the runoff from plot D, so the beans in plot D are absorbing/taking up less fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because the plants in plot B were able to produce more beans given the same amount of fertilizer.

- (g) **Describe** the ecological process that occurred on the plots after the crops were burned. **1 point**

Accept one of the following:

- Fast growing/early successional organisms returned to/colonized the soil after the fire/major disturbance.
- Secondary succession occurred where plants recolonize a habitat after the fields were burned/after a major disturbance.

- (h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding. **1 point**

Accept one of the following:

- The plot with higher diversity/richness has more species/organisms, so the floods harm a smaller proportion of the species/organisms.
- The plot with higher diversity/richness has more connections between organisms, so the floods disrupt a smaller percentage of the connections between organisms.
- The plot with higher genetic diversity within species may have more flood tolerant individuals that will survive a flood.

- (i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could. **1 point**

Accept one of the following:

- The new beetle is a generalist/r-selected species and could more quickly populate the area/outcompete the existing/native beetle species.
- The flooding of the plot caused a natural disruption to the existing community, eliminating species/natural predators and opening niches for the new/invasive beetle.
- Low diversity communities are susceptible to disruption and can't recover allowing the new/nonnative beetle species to invade
- The new beetle is an invasive species that can live outside its normal environment and threaten native species

- (j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot. **1 point**

Accept one of the following:

- Remove beetles by trapping/physical removal to reduce their population size.
- Apply a chemical/pesticide to kill beetles.
- Add a predator/parasite/pathogen/biological control that harms beetles.

Total for question 1 10 points

Question 2: Analyze an Environmental Problem and Propose a Solution 10 points

(a)	Based on the information in the diagram, identify the temperature range of the water through which the majority of the adult manatee’s daily movement occurs. • 13–19°C	1 point
(b)	Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, identify a characteristic of the power plant waste water that would attract the manatees. Accept one of the following: • The waste water/It is warm. • The waste water/It is between 24–26°C.	1 point
(c)	Based on the information in the diagram, describe a potential negative impact of the waste water released by the power plant on other aquatic species. Accept one of the following: • Warming of the water near where the waste water/it is released reduces the amount of dissolved oxygen available for aquatic organisms to use/breathe. • Warming of the water near where the waste water/it is released could impact the survival/health of species with a range of tolerance for the original/lower water temperatures. • Warming of the water near where the waste water/it is released could alter/affect the timing of reproductive cycles for aquatic species.	1 point
(d) (i)	Describe a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses. Accept one of the following: • They eat seagrass/are herbivores, so they would have less food/starve. • They require a lot of energy to survive, so they would have less food/starve. • They inhabit warm water, so they would need to travel to colder waters/further to find food/seagrass. • They have a low reproductive/maturation rate, so they would take longer to recover from loss of food source.	1 point
(d) (ii)	Describe the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses. Accept one of the following: • Less energy will flow/is available to organisms in higher trophic levels. • Less energy from the Sun is stored by producers.	1 point
Total for part (d)		2 points

(e) (i)	Propose a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development. Accept one of the following: • Replace existing pavement with permeable pavement. • Add vegetation where it will intercept runoff. • Reduce fertilizer use in the area. • Install barriers/Construct fences where they will intercept runoff. • Improve wastewater treatment plants in the area.	1 point
(e) (ii)	Justify the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees. Accept one of the following: • Reduces eutrophication. • Increases biodiversity/species richness. • Improves water clarity. • Increases ecotourism. • Reduces cost of water treatment. • Increases profits for commercial fisherman.	1 point
Total for part (e)		2 points
(f)	Describe how summertime weather conditions can increase the frequency of photochemical smog. Accept one of the following: • Sunlight is more intense/there is more sunlight in summer, and more primary pollutants/nitrogen oxides/NO _x react in sunlight. • Summertime temperatures are warmer than other seasons, and chemical reactions occur more quickly in warmer temperatures. • Trees release more VOCs in summer leading to more reactions that form photochemical smog.	1 point
(g)	Identify one ecological problem that results from exposure to photochemical smog. Accept one of the following: • Causes respiratory problems/eye irritation in animals. • Reduces photosynthesis. • Slows/Inhibits/Stunts plant growth. • Increases the susceptibility of plants to pests and disease.	1 point

(h) **Describe** a potential disadvantage of using hydrogen fuel cells to power automobiles. **1 point**

Accept one of the following:

- High cost to manufacture automobiles that use hydrogen fuel cells.
- Obtaining hydrogen requires a lot of energy/may consume more energy than the hydrogen fuel can produce.
- Hydrogen is explosive/flammable (may catch fire).
- Lack of infrastructure (such as fueling stations) for hydrogen fuel.
- Obtaining hydrogen often uses fossil fuels.
- Hydrogen must be obtained by separating it from natural gas or water.

Total for question 2 10 points

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

10 points

(a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil. **1 point**

Accept one of the following:

- Marine life is harmed/killed by being coated/suffocated by oil from spills.
- Animals are harmed/killed by ingesting spilled oil.
- Oil slicks from spills can block sunlight from entering water and inhibit photosynthesis.
- Oil that washes up on beaches/in marshes/in estuaries damages habitat.
- Noise pollution disrupts marine animals' ability to communicate/mate/eat/evade prey.
- CO₂ from combustion of fuels in boats/equipment is absorbed by ocean and contributes to ocean acidification.

(b) **Identify** an atmospheric pollutant released during the combustion of refined oil products. **1 point**

Accept one of the following:

- Carbon dioxide (CO₂)
- Nitrogen oxides (NO_x, NO, NO₂, N₂O)
- Sulfur oxides (SO_x, SO₂, SO₃)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Volatile Organic Compounds (VOCs)

(c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation. **1 point**

Accept one of the following:

- Ride a bike/scooter/skateboard or walk instead of driving.
- Replace a gasoline/diesel powered car with a hybrid or electric vehicle.
- Replace a gasoline/diesel powered car with one that utilizes alternative fuel (biodiesel, ethanol, hydrogen).
- Buy/Drive a more fuel-efficient vehicle.
- Work from home/telecommute to reduce miles driven.
- Choose housing that is close to employment to reduce miles driven.
- Take public transportation instead of driving.
- Carpool instead of driving alone.
- Combine trips to reduce miles driven.

- (d) Justify** the solution proposed in part (c) by providing a benefit to human health. **1 point**

Accept one of the following:

Solution proposed in part (c)	Justification of solution with additional advantage
Replace a gasoline powered car with a hybrid or electric vehicle. Replace a gasoline/diesel powered car with one that utilizes an alternative fuel. Buy/Drive a more fuel-efficient vehicle. Work from home/telecommute to reduce miles driven. Choose housing that is close to employment to reduce miles driven. Take public transportation instead of driving. Carpool instead of driving alone. Combine trips to reduce miles driven.	- Fewer air pollutants (particulates, NO_x, VOCs, smog) leads to lower rates of - respiratory illness/problems such as asthma, COPD, lung cancer. - cardiovascular illness such as heart attacks. - eye irritation.
Ride bike/scooter/skateboard or walk instead of driving.	- Fewer air pollutants (particulates, NO_x, VOCs, smog) leads to lower rates of - respiratory illness/problems such as asthma, COPD, lung cancer. - cardiovascular illness such as heart attacks. - eye irritation. - Improved health/Decreased risk of disease/cardiovascular illness from more physical activity/exercise.

- (e)** A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work. **1 point**

One point for the correct setup to calculate the number of grams of gold that could be extracted from the gold deposit:

Accept one of the following:

- $260 \text{ million metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $260 \times 10^6 \text{ metric tons} \times 5 \text{ grams}$
- $5 \times 260,000,000$

One point for the correct calculation of the number of grams of gold that could be extracted from the gold deposit: **1 point**

Accept one of the following:

- 1,300,000,000
- 1.3×10^9

Total for part (e) 2 points

- (f)** Assuming the price of gold is \$62.56 per gram, **calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work. **1 point**

One point for the correct setup to calculate the value of the gold that could be recovered:

Accept one of the following:

- $\frac{\$62.56}{1 \text{ gram}} \times 1,000 \text{ metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $\$62.56 \times 1,000 \text{ metric tons} \times 5 \text{ grams}$
- $\frac{\$62.56}{\text{g}} \times \frac{5 \text{ g}}{\text{metric ton}} \times 1,000$
- $1,000 \times 5 \times \$62.56$

One point for the correct calculation of the value of gold that could be recovered: **1 point**

Accept one of the following:

- \$312,800
- 312,800 dollars

Total for part (f) 2 points

(g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold **1 point**

ore would need to be mined to extract enough gold to manufacture 100,000 cell phones.

Show your work.

One point for the correct setup to calculate the number of metric tons of gold ore that would need to be mined to manufacture 100,000 cell phones:

Accept one of the following:

- $\frac{0.034 \text{ grams}}{1 \text{ cell phone}} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000 \text{ cell phones}$
- $\frac{0.034 \text{ grams}}{1 \text{ cell phone}} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000$
- $0.034 \text{ grams} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100,000$
- $\frac{0.034 \times 100,000}{5}$

One point for the correct calculation of the number of metric tons of gold ore that would **1 point**

need to be mined to manufacture 100,000 cell phones:

- 680

Total for part (g) 2 points

Total for question 3 10 points