

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

10 points

(a) **Identify** a fuel used in a nuclear power plant. 1 point

Accept one of the following:

- Uranium
- U-235
- Plutonium

(b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants. 1 point

Accept one of the following:

- Thermal pollution raises water temperature outside range of tolerance of organisms.
- Thermal pollution decreases dissolved oxygen.
- Water temperature increases, which decreases dissolved oxygen.
- Organisms can be wounded or killed at water intake.
- Water loss through evaporation can decrease stream flow/volume of water.

(c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work. 1 point

One point for the correct setup to calculate the amount of electricity generated by nuclear power in 2021:

Accept one of the following:

- $(4.1 \times 10^{12} \text{ kWh}) \times 18.9\%$
- $(4.1 \times 10^{12}) \times 0.189$
- $\frac{4.1 \times 10^{12}}{100} = \frac{x}{18.9}$

One point for the correct calculation of the total amount of electricity generated by nuclear power in 2021: 1 point

Accept one of the following:

- 774,900,000,000
- 7.749×10^{11}
- 7.75×10^{11}
- 7.7×10^{11}

Total for part (c) 2 points

(d)	In addition to reducing greenhouse gas emissions, describe how switching from coal-burning power plants to natural gas power plants will improve air quality. There is less NO_x/SO_x/ash/particulates/toxic metals/smog formed from the burning of natural gas compared to coal.	1 point
(e)	Justify the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases. Accept one of the following: - Trees can provide forest habitat/increase biodiversity/diversify niches in the area. - Creates jobs for planting trees/recreational industries/harvesting wood. - Trees create a more aesthetically pleasing environment/enhance cultural ecosystem services. - Planting trees can decrease soil loss/erosion/sedimentation in waterways. - Trees can provide shade/decrease ambient temperature. - Planting trees slows water runoff/reduces flooding.	1 point
(f)	7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. Calculate how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. Show your work. One point for the correct setup to calculate how many homes could have been provided with electricity by natural gas: Accept one of the following: $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{1 \text{ m}^3} \times \frac{1 \text{ home}}{10,715 \text{ kWh}}$ $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{10,715 \text{ kWh}}$ $(7.4 \times 10^7) \times \frac{4.76}{10,715}$ One point for the correct calculation of how many homes could have been provided with electricity by natural gas: Accept one of the following: 32,874 32,873 33,000	1 point
	Total for part (f)	2 points

- (g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. **1 point**
 One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

One point for the correct setup to calculate how much less carbon dioxide would have been produced in 2021:

Accept one of the following:

- $\frac{(1.0 \text{ kg} - 0.42 \text{ kg})}{1 \text{ kWh}} \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 \text{ kg} - 0.42 \text{ kg}) \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 - 0.42) \times (8.99 \times 10^{11})$
- $\left(\frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{1 \text{ kg}}{\text{kWh}} \right) - \left(\frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{0.42 \text{ kg CO}_2}{\text{kWh}} \right)$, THEN
 $8.99 \times 10^{11} \text{ kg CO}_2 - 3.776 \times 10^{11} \text{ kg CO}_2$

One point for the correct calculation of how much less carbon dioxide would have been produced in 2021: **1 point**

Accept one of the following:

- 521 billion kg
- 521,420,000,000 kg
- $5.2142 \times 10^{11} \text{ kg}$
- $5.21 \times 10^{11} \text{ kg}$
- $5.2 \times 10^{11} \text{ kg}$

Total for part (g) 2 points

Total for question 3 10 points

Question 1: Design an Investigation**10 points**

(a) **Identify** the ecological change over time illustrated in the diagram. **1 point**

- Primary Succession

(b) **Identify** the stage in which pioneer species first appear. **1 point**

- II/2

(c) **Describe** how soil forms from stage II to stage III. **1 point**

Accept one of the following:

- Wind/rain/weather can erode the rock/parent material.
- Wind/rain can break down rocks.
- Pioneer species (lichen/algae/fungi) die off adding small amounts of organic material.
- Pioneer species (lichens/algae/fungi) help break down rocks.

(d) **Identify** a cultural ecosystem service that may be provided by a mature forest. **1 point**

Accept one of the following:

- Recreation
- Aesthetic enjoyment
- Spiritual use
- Ecotourism
- Education

(e) **Identify** a testable hypothesis being investigated by the researchers. **1 point**

Accept one of the following:

- The removal of trees/clear-cutting will lead to an increase/decrease in water quality (temperature/turbidity/dissolved oxygen).
- The removal of trees/clear-cutting will have no effect on water quality (temperature/turbidity/dissolved oxygen).
- Water quality (temperature/turbidity/dissolved oxygen) will increase/decrease between stations.
- Water quality (temperature/turbidity/dissolved oxygen) will not change between stations.

(f) **Identify** the independent variable in the experiment. **1 point**

Accept one of the following:

- Presence or absence of clear-cutting
- Intact or clearcut forest
- Location of stream monitoring stations

(g)	Describe the purpose of forest A in the experiment.	1 point
	Accept one of the following: • Forest A/It is included so the researchers can compare the temperature/turbidity/water quality in clear-cut areas (forest B) to intact areas. • Forest A/It acts as a control so researchers can compare intact areas/Forest A to clear-cut areas/Forest B.	
(h)	Explain why the water temperature might change because of clear-cutting trees in forest B.	1 point
	Accept one of the following: • Water temperature will increase because there will be no/fewer trees to block the sunlight. • Water temperature will increase because there will be additional sediment from erosion. • Water temperature will increase because more sunlight will reach the water surface.	
(i)	Explain why an indicator of water quality other than temperature could be altered by the golf course in forest B.	1 point
	Accept one of the following: • There could be a decrease in dissolved oxygen because fertilizer runoff leads to algal blooms/eutrophication. • There could be a decrease in sedimentation/turbidity because the grass will decrease erosion compared to the clear-cut land. • There could be an increase in nitrates/phosphates due to fertilizer runoff resulting in algal growth/bloom.	
(j)	Explain how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course.	1 point
	Accept one of the following: • Aquatic organisms would die off from a lack of oxygen created by the decomposition of algae/eutrophication. • Aquatic organisms would survive at a higher rate because there is less sediment to suffocate them/clog their gills. • Aquatic organisms would die off due to increased toxicity from pesticide runoff.	

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. **1 point**

- 13–19°C

(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. **1 point**

Accept one of the following:

- The waste water/It is warm.
- The waste water/It is between 24–26°C.

(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. **1 point**

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.

(d) (i) **Describe** a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses. **1 point**

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.

(d) (ii) **Describe** the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses. **1 point**

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.

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.	1 point
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.		
(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.	1 point
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.		
Total for part (e)		2 points
(f)	Describe how summertime weather conditions can increase the frequency of photochemical smog.	1 point
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.		
(g)	Identify one ecological problem that results from exposure to photochemical smog.	1 point
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.		

(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