AP Environmental Science
Scoring Guidelines
Set 1

Question 1: Design an Investigation   10 points

(a)	Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen.	**1 point**

- Zone C/C

(b)	Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.	**1 point**

Accept one of the following:

- As biological oxygen demand increases, dissolved oxygen decreases.
- As biological oxygen demand decreases, dissolved oxygen increases.
- As dissolved oxygen increases, biological oxygen demand decreases.
- As dissolved oxygen decreases, biological oxygen demand increases.

(c)	Based on the information in the diagram, **identify** the zone where there is likely point-source water pollution discharged into the stream.	**1 point**

- Zone B/B

(d)	**Identify** the dependent variable in the researchers' investigation.	**1 point**

Accept one of the following:

- The number of macroinvertebrate species
- Macroinvertebrate diversity
- Macroinvertebrate species richness

(e)	**Identify** a testable hypothesis for the researchers' investigation.	**1 point**

Accept one of the following:

- As dissolved oxygen levels increase, the number of macroinvertebrate species increases.
- As dissolved oxygen levels decrease, the number of macroinvertebrate species increases.
- There is a direct/inverse relationship between dissolved oxygen levels and the number of macroinvertebrate species.
- There is no relationship between biological oxygen demand and macroinvertebrate biodiversity.

(f)	**Describe** the reason the researchers selected zone A to serve as the control in the investigation.	**1 point**

Accept one of the following:

- Zone A/A/It is upstream from the source of pollution/organic waste/discharge/change.
- Zone A/A/It would not be affected by the source of pollution/organic waste/discharge/change.
- Zone A/A/It has levels of dissolved oxygen that are not impacted by the source of pollution/organic waste/discharge/change.

(g)	**Explain** how the modification to collect data in the winter months could alter the results of the investigation.	**1 point**

Accept one of the following:

- Cold water will have more dissolved oxygen, which could increase the number of species.
- Colder water may be below the range of tolerance for some of the organisms, which could decrease the number of species.
- Lower light levels in the winter decrease plant activity/photosynthesis, which lowers dissolved oxygen levels, which could decrease the number of species.

(h)	**Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.	**1 point**

Accept one of the following:

- Raw sewage contains nutrients that could increase the population of bacteria.
- Raw sewage contains bacteria that could increase the population size.

(i)	**Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.	**1 point**

Accept one of the following:

- Temperature
- pH
- Light/Sunlight
- Turbidity/Sediment
- Salinity
- Nitrate/Phosphate

(j)	**Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.	**1 point**

Accept one of the following:

- Persistent organic pollutants/Pollutants can bioaccumulate in the tissues of organisms at higher trophic levels because they consume prey that have accumulated the pollutants.
- Persistent organic pollutants/Pollutants can accumulate/concentrate in the tissues of organisms at higher trophic levels because they consume prey that have accumulated the pollutants.
- Persistent organic pollutants/Pollutants can bioaccumulate in organisms at higher trophic levels because of higher fat content in their tissues.
- Organisms at higher trophic levels can experience neurological toxicity because persistent organic pollutants bioaccumulate.

Total for question 1   10 points

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

(a)	Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein.	**1 point**
	• 50 m²	

(b)	Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle.	**1 point**
	• Type III	

(c)	**Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population.	**1 point**
	Accept one of the following:	
	• Darkling beetles reproduce quickly, which allows for a large amount of protein to be produced in a short period of time.	
	• Darkling beetles have many offspring, which allows for a large amount of protein to be produced in a short period of time.	

(d)	Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage.	**1 point**
	Accept one of the following:	
	• Chicken production has a lower global warming potential than pork production, so it would cause less environmental damage because chicken production releases less greenhouse gas.	
	• Chicken production has a lower land use than pork production, so it would cause less environmental damage because there would be less deforestation/habitat destruction/soil erosion/fossil fuel use.	

(e)	Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have.	**1 point**
	Accept one of the following:	
	• Beef has a larger impact because methane has a high global warming potential.	
	• Beef has a larger impact because methane is a greenhouse gas.	
	• Beef requires more land use, which results in loss of forests/habitat/grasslands leading to release of CO_2/reduction in carbon storage.	

(f)	**Describe** how water quality can be altered by cattle grazing that occurs near a stream or river.	**1 point**

Accept one of the following:

- Cattle cause erosion, which increases sedimentation/turbidity in water.
- Cattle feces can add nutrients/nitrogen/phosphorus to waterways.
- Cattle feces may contaminate waterways with bacteria.

(g)	**Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze.	**1 point**

Accept one of the following:

- Practice rotational grazing/alternate grazing parcels.
- Eat a diet with less meat/beef.
- Fence/barricade the riparian zone.
- Provide other water sources for the cattle.

(h)	Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion.	**1 point**

Accept one of the following:

- Switch crops to perennial plants.
- Plant crops on terraces.
- Implement contour plowing/farming.
- Use no-till farming/cover crops.

(i)	**Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion.	**1 point**

Accept one of the following:

Solution proposed in (h)	Justification of solution with additional advantage other than the reduction of soil erosion
Switch to perennial plants	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils.
Plant crops on terraces	• Allows areas to be farmed that are otherwise too steep. • Sediments and other contaminants settle out behind the terrace ridge reducing the amount of soil that runs off. • Increases groundwater absorption.
Implement contour plowing/farming	• Allows areas to be farmed that are otherwise too steep. • Increases groundwater absorption.
Use no-till farming/cover crops	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils. • Cover crops can be used as green manure.

(j)	Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change.	**1 point**

Accept one of the following:

- Crop production/yields could decrease because of:
  - Increased drought
  - Increased flooding
  - Increased insect infestation from warmer temperatures
  - Increased temperature
  - Changes in seasonal rain patterns (or temperatures)
  - Expansion of geographic range of invasive pests/species
  - Climate may be outside range of tolerance of crops

Total for question 2   10 points

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:

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

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. | **1 point** |

- There is less NO_X/SO_X/ash/particulates/toxic metals/smog formed from the burning of natural gas compared to coal.

| (e) | **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases. | **1 point** |

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.

| (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. | **1 point** |

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:

- $\left(7.4 \times 10^7 \, m^3\right) \times \dfrac{4.76 \text{ kWh}}{1 \, m^3} \times \dfrac{1 \text{ home}}{10,715 \text{ kWh}}$

- $\left(7.4 \times 10^7 \, m^3\right) \times \dfrac{4.76 \text{ kWh}}{10,715 \text{ kWh}}$

- $\left(7.4 \times 10^7\right) \times \dfrac{4.76}{10,715}$

| One point for the correct calculation of how many homes could have been provided with electricity by natural gas: | **1 point** |

Accept one of the following:

- 32,874
- 32,873
- 33,000

| | **Total for part (f)** | **2 points** |

(g)	In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. 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.	**1 point**

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

Accept one of the following:

- $\dfrac{(1.0 \text{ kg} - 0.42 \text{ kg})}{1 \text{ kWh}} \times \left(8.99 \times 10^{11} \text{ kWh}\right)$

- $(1.0 \text{ kg} - 0.42 \text{ kg}) \times \left(8.99 \times 10^{11} \text{ kWh}\right)$

- $(1.0 - 0.42) \times \left(8.99 \times 10^{11}\right)$

- $\left(\dfrac{8.99 \times 10^{11} \text{ kWh}}{1} \times \dfrac{1 \text{ kg}}{\text{kWh}}\right) - \left(\dfrac{8.99 \times 10^{11} \text{ kWh}}{1} \times \dfrac{0.42 \text{ kg CO}_2}{\text{kWh}}\right)$, 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
- 5.2142×10^{11} kg
- 5.21×10^{11} kg
- 5.2×10^{11} kg

Total for part (g)	**2 points**
Total for question 3	**10 points**