

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

A **Describe** one reproductive strategy used by a K-selected species such as the chickadee. **Point 01**

Examples of acceptable responses may include the following:

- (K-selected species) provide considerable parental care for offspring.
- (K-selected species) have few offspring.
- (The parents) expend significant energy for each offspring.
- (Individuals) reproduce more than once in their lifetime.
- (K-selected species) have a long gestation period/reach reproductive maturity later.

B Based on the information provided, **explain** how a decrease in spider populations could affect a lower trophic level. **Point 02**

Examples of acceptable responses may include the following:

- Insects/insect populations would increase because the insects are not being preyed on/eaten as much.
- Plants/plant populations would decrease because the number of insects that eat plants will increase.

C Based on the data in Figure 1, **identify** the number of spiders per sample at 25% nonnative plants. **Point 03**

Examples of acceptable responses may include the following:

- 2.0
- 2

D Based on the data in Figure 1, **describe** the trend in the number of insects per sample in relation to the percentage of nonnative plants. **Point 04**

Examples of acceptable responses may include the following:

- As nonnative plant percentage/percent increases, the number of insects decreases.
- As nonnative plant percentage/percent decreases, the number of insects increases.
- They have an inverse/indirect/negative relationship.

E Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. **Describe** one way that the data in Figure 2 support this hypothesis. **Point 05**

Examples of acceptable responses may include the following:

- Below this level/With fewer than 25%, the growth rate is at/above replacement level.
- Below this level/With fewer than 25%, enough reproduction is occurring to replace the population.
- Below this level/With fewer than 25%, the population growth rate is positive.

F	(i) Identify a likely scientific question for the students' investigation of ant diversity. Point 06 Examples of acceptable responses may include the following: - Does the number of species/species richness/biodiversity differ between an urban park and a grassland? - Does mowing affect the number of species/species richness/biodiversity?
	(ii) Identify the dependent variable in the students' investigation. Point 07 Examples of acceptable responses may include the following: - Number of ant species - Ant species richness - Presence/absence of different ant species
G	(i) Explain why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would. Point 08 Examples of acceptable responses may include the following: - With a larger number of species, the grassland is more likely to have some species/individuals with adaptations that allow them to survive. - The grassland is more diverse, so the loss of one species is less likely to cause a collapse (of the whole ecosystem).
	(ii) Explain how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland. Point 09 Examples of acceptable responses may include the following: (The playground) would have fewer species (than the grassland/urban park) because the paved area is not suitable habitat for many ant species. (The playground) would have fewer species (than the grassland/urban park) because humans could trample the ants/ant habitat.
H	Describe one effect a paved road in a forest can have on animal species such as deer or bears. Point 10 Examples of acceptable responses may include the following: - Animals can get hit by cars when trying to cross the road/hunt/migrate. - Fragmentation can lead to isolation of individuals/loss of genetic diversity. - Noise pollution can damage hearing/cause stress/mask the sounds used to communicate/hunt. - The road/noise pollution can cause changes in migratory routes/prevent movement of animals (to access resources). - Species that thrive in edge habitats might increase.

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

A	Based on the information in Figure 1, identify the type of plate boundary that runs beneath Serengeti National Park. Acceptable identification point: • Divergent (boundary)	Point 01
B	Based on the information provided, identify the dominant biome within the Serengeti. Examples of acceptable responses may include the following: • Savanna • Tropical grassland	Point 02
C	Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, identify the location in the Serengeti where wildebeest are most likely to give birth. Examples of acceptable responses may include the following: • Grumeti Game Reserve • The west/northwestern side/edge (of Serengeti National Park)	Point 03
D	Explain why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti. Examples of acceptable responses may include the following: • (Resource partitioning) reduces the (negative) impact of competition for (limited) resources. • (Resource partitioning) allows species to use (limited) resources in different ways/places/at different times.	Point 04
E	Describe one way the proposed highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti. Examples of acceptable responses may include the following: • Building the highway would fragment/destroy habitat/food/resources. • The highway could prevent/reduce/disturb migration. • Wildebeest could be hit/killed by vehicles. • Noise pollution could cause stress/change migratory routes.	Point 05

F **Propose** a solution to the negative effect created by the planned highway described in part E. **Point 06**

Examples of acceptable responses may include the following:

Problem in part E	Realistic Potential Solution
Building the highway would fragment/destroy habitat/food/resources.	- Construct a habitat corridor over/under the highway - Construct the highway over/above the habitat - Relocate the highway north/outside of the migratory path - Expand the national park/create additional protected habitat
The highway could prevent/reduce/disturb migration. Wildebeest could be hit/killed by vehicles.	- Relocate the highway north/outside of the migratory path - Construct a habitat corridor over/under the highway
Noise pollution could cause stress/change migratory routes.	- Install a sound barrier to mitigate noise pollution - Relocate the highway north/outside of the migratory path

G **Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species. **Point 07**

Examples of acceptable responses may include the following:

- They have many offspring/reproduce quickly/mature early/invest minimal energy in each offspring (tend to be r-selected).
- They can feed on/use many different types of resources.
- They can survive in conditions outside their normal habitat/have a wide range of tolerance (tend to be generalists).

H **Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations. **Point 08**

Examples of acceptable responses may include the following:

- Improved soil fertility/soil structure/soil quality
- Increased nutrient cycling/reduction in fertilizer use
- Reduced soil erosion
- Increased food security/crop yield
- Increased biological activity (in the soil)

I	Describe an environmental problem associated with controlling pest populations with large amounts of pesticide. Examples of acceptable responses may include the following: • Pesticides can harm/kill nontarget species. • Pests can develop resistance to the pesticide.	Point 09
J	Propose a solution to controlling pests, other than pesticides or crop rotation. Examples of acceptable responses may include the following: • Use biocontrol/intercropping/natural predators • Trap insects/use mechanical controls to eliminate the pests • Use genetically modified crops that are pest resistant	Point 10

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