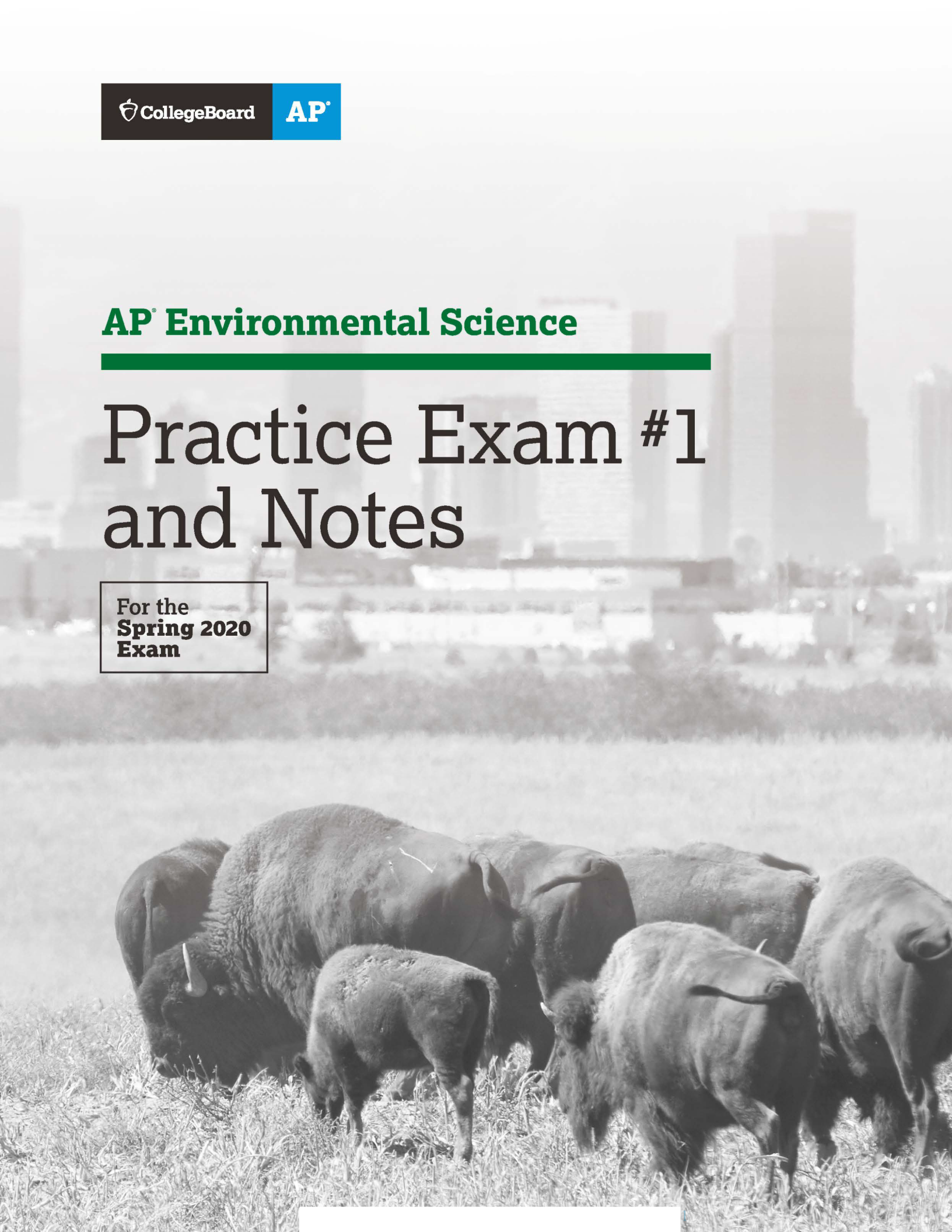
CollegeBoard AP

AP® Environmental Science

Practice Exam #1 and Notes

For the **Spring 2020 Exam**



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Practice Exam

Exam Content and Format

The AP Environmental Science Exam is 2 hours and 40 minutes long. There are two sections:

- Section I is 1 hour, 30 minutes and consists of 80 multiple-choice questions, accounting for 60 percent of the final score.
- Section II is 1 hour, 10 minutes and consists of 3 free-response questions accounting for 40 percent of the final score.

Administering the Practice Exam

This section contains instructions for administering the AP Environmental Science Practice Exam. You may wish to use these instructions to create an exam situation that resembles an actual administration. If so, read the indented, boldface directions to the students; all other instructions are for administering the exam and need not be read aloud. Before beginning testing, have all exam materials ready for distribution. These include test booklets and answer sheets. (Reminder: Final instructions for every AP Exam are published in the AP Exam Instructions book.)

SECTION I: Multiple Choice

When you are ready to begin Section I, say:

> **Section I is the multiple-choice portion of the exam. Mark all of your responses on your answer sheet, one response per question. If you need to erase, do so carefully and completely. Your score on the multiple-choice section will be based solely on the number of questions answered correctly.**
>
> **You have 1 hour and 30 minutes for this part. Open your Section I booklet and begin.**

Note Start Time here _____. Note Stop Time here _____. After 1 hour and 20 minutes, say:

> **There are 10 minutes remaining.**

After 10 minutes, say:

> **Stop working. I will now collect your Section I booklet and multiple-choice answer sheet.**

There is a 10-minute break between Sections I and II.

SECTION II: Free Response

After the break, say:

> **Section II is the free-response portion of the exam.**
>
> **You have 1 hour and 10 minutes to complete Section II. You may use the blank page 3 to organize your answers and for scratch work, but you must write your answers on the lined pages provided for the free-response questions. Open your Section II booklet and begin.**

Note Start Time _____. Note Stop Time _____. After 1 hour and 10 minutes, say:

> **Stop working and close your exam booklet. Put your exam booklet on your desk, face up. Remain in your seat, without talking, while the exam materials are collected.**

Collect a Section II booklet from each student and check that each student wrote his or her answers on the lined pages corresponding to each question. Then say:

> **The exam is over. You are now dismissed.**

Name: .....

AP® Environmental Science
Answer Sheet
for Multiple-Choice Section

No.	Answer
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AP® Environmental Science Exam

SECTION I: Multiple Choice

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour and 30 minutes
Number of Questions
80
Percent of Total Score
60%
Writing Instrument
Pencil required
Electronic Device
Calculator allowed

Instructions

Section I of this exam contains 80 multiple-choice questions.

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work.

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all of the multiple-choice questions.

Your total score on the multiple-choice section is based only on the number of questions answered correctly. Points are not deducted for incorrect answers or unanswered questions.

ENVIRONMENTAL SCIENCE

SECTION I

Time—1 hour and 30 minutes

80 Questions

Part A

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement and then enter the letter in the corresponding space on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1 - 3 refer to the following sources of energy.

(A) Solar Energy
(B) Wind Energy
(C) Geothermal Energy
(D) Nuclear Energy

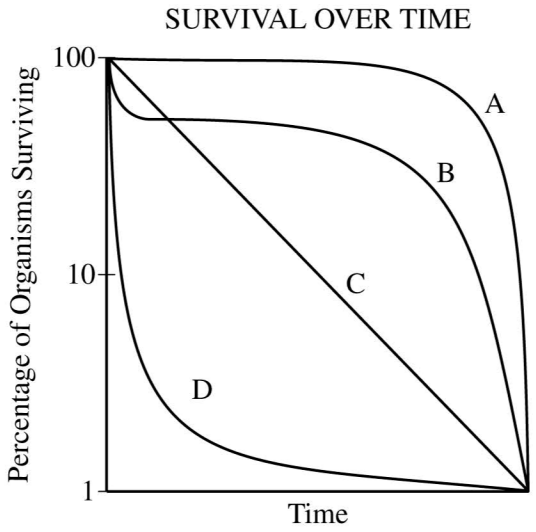
1. This type of energy is considered a nonrenewable energy source.

2. This type of energy utilizes heat that is stored beneath Earth's surface to heat water and produce steam.

3. This energy source is used to generate electricity with photovoltaic (PV) cells.

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Questions 4 - 6 refer to the graph below.



4. Which curve in the graph best represents a K-selected species?

5. Dandelions grow quickly and produce many seeds, ensuring that at least some plants will survive and produce seeds themselves. Which curve best represents the survivorship of dandelions?

6. Certain lizards display a survivorship curve where the chance of survival is independent of age. Which line on the graph best depicts the survivorship of these lizards?

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Questions 7 - 9 refer to the world map below.



7. This is the location of the world's largest hydroelectric dam, with a generating capacity of 22,500 MW.

8. At this site a 9.0 magnitude earthquake, which occurred at a nearby subduction zone, triggered one of the largest nuclear reactor disasters in history.

9. Geothermal energy is the main energy source at this location because it is located on a large divergent boundary.

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Questions 10 - 12 refer to the following types of irrigation.

(A) Drip irrigation
(B) Flood irrigation
(C) Furrow irrigation
(D) Spray irrigation

10. This type of irrigation is often used by small-scale farming operations and it requires extensive labor to set up individual irrigation lines.

11. This type of irrigation uses a large system of sprinklers that must be manually moved from field to field and has very large evaporative losses.

12. This type of irrigation, often used in orchards growing tree crops, distributes water to plants through small parallel channels between crop rows but often leads to increased soil erosion in the field.

GO ON TO THE NEXT PAGE.

Part B

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then enter the letter in the corresponding space on the answer sheet.

13. Which of the following is the best example of a tragedy of the commons?

    (A) Depletion of crude oil on private lands
    (B) Requiring permits for grazing cattle on United States parklands
    (C) Eutrophication of a pond on a farmer's land
    (D) Accumulation of plastics in the Great Pacific Garbage Patch

14. Which of the following correctly pairs a greenhouse gas with its primary anthropogenic source?

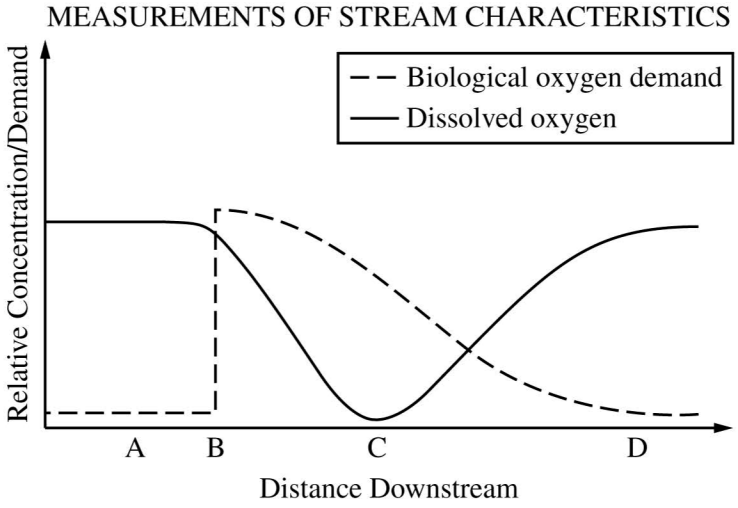
    (A) Methane and vehicular emissions
    (B) Nitrous oxide and agricultural practices
    (C) Chlorofluorocarbons and fossil fuel combustion
    (D) Carbon dioxide and municipal solid waste from homes

15. Which of the following best describes a disadvantage of using genetically engineered crops over crops that are not genetically modified?

    (A) Genetically engineered plants can decrease the genetic diversity of the crop.
    (B) Genetically engineered plants require greater use of pesticides.
    (C) Genetically engineered plants require more land to grow on.
    (D) Genetically engineered plants are more likely to spread disease throughout the crop.

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16. The graph shows how biological oxygen demand (BOD) and dissolved oxygen (DO) concentration change over the length of a stream. Points A–D indicate different locations within the stream.



At which of the following locations in the stream was there most likely a discharge of excess organic matter into the water?

(A) A
(B) B
(C) C
(D) D

GO ON TO THE NEXT PAGE.

NO TEST MATERIAL ON THIS PAGE

Questions 17 - 20 refer to the article below.

How New York City Is Turning Its Thousands of Roofs Into Power Providers

New York City is home to thousands of acres of rooftop [and] some of the most expensive electricity in the country.... Yet New York has been slower than other big cities in tapping into one constant source of clean energy: the sun.

Now though... some of the biggest expanses of flat roof in New York are being turned into sources of cheap and green electricity.

This year, the corporate owner of Stuyvesant Town-Peter Cooper Village in Manhattan completed the installation of the country's largest array of solar panels on an apartment complex. And soon, the Bronx could have an even larger one, at the massive Co-Op City complex.

...

In June, the state said that it aimed for 70 percent of its power to be generated from renewable sources by 2030. Two months before, the New York City Council passed an ordinance that will require most new buildings to be topped with solar panels or roofs covered in grass or other vegetation.

...

The project at StuyTown, as the complex is known, incorporated more than 9,000 solar panels onto 56 rooftops, making it by far the biggest in Manhattan. It effectively doubled the borough's solar capacity, adding 3.9 megawatts, or enough to power more than 1,100 apartments....

...

The city and state have driven much of the investment in solar power by providing tax breaks and other incentives to homeowners and landlords. The state incentives began in 2014 with a goal of creating 3 gigawatts — 3,000 megawatts — of solar capacity statewide by 2023.

...

Still, the projects illustrate the limitations so far of solar power, given that they would produce only a fraction of the electricity consumed on their own sites.

...

But even though not enough energy is generated to power all of the [StuyTown] complex, the solar energy will take pressure off the power distribution network on hot summer days when demand from ... customers is peaking....

...

New York now ranks sixth among American cities in the capacity of its installed solar panels, according to Environment America, an advocacy group. Still, its total of about 200 megawatts is less than half of the capacity in Los Angeles, which has the highest capacity of any city in the country.

...

How New York City is Turning Its Thousands of Roofs Into Power Providers, Patrick McGeehan, The New York Times, July 10, 2019

GO ON TO THE NEXT PAGE.

17. Based on the article, which of the following best identifies the author's claim?

    (A) A decrease in available rooftop space in New York City is pushing the city's solar farms to the Midwest.

    (B) Increased tax breaks and other financial incentives have been an important factor for increasing the number of installations of solar panels on New York City rooftops.

    (C) Efforts to install solar panels on New York City rooftops should be discontinued because insufficient solar energy is produced.

    (D) Current projects for installing solar panels on rooftops of apartment buildings in New York City need to be reconsidered because of criticism from apartment residents.

18. Which of the following best describes the author's perspective on the use of solar energy in New York City?

    (A) The high cost associated with the installation and maintenance of solar panels is barely offset by citywide savings in electricity generation.

    (B) Since New York City has risen to the position of sixth highest American city for total solar capacity, officials should temporarily limit more solar installations to minimize costs to residents.

    (C) New York City is behind other major cities in its use of solar energy in electricity generation and should continue efforts to increase its solar capacity.

    (D) City officials should invest in energy alternatives other than solar power because New York City has some of the highest electricity costs in America.

19. Which of the following pieces of evidence does the author use to support the claim that the solar panel installation on the StuyTown complex is the largest in Manhattan?

    (A) The StuyTown project increased the solar capacity of the city to 3.9 megawatts.

    (B) The installation added 9,000 solar panels to 56 rooftops, effectively doubling the total solar capacity of the surrounding area.

    (C) New York City now has around 200 megawatts more in total solar capacity than Los Angeles does.

    (D) After completion of the StuyTown project, the state attributed 70% of its power generation to solar energy.

20. Currently, the rooftop solar panels produce only a fraction of the electricity used in the buildings on which they are installed. Which of following strategies would best combat the problem of insufficient electricity generation from the rooftop solar panels?

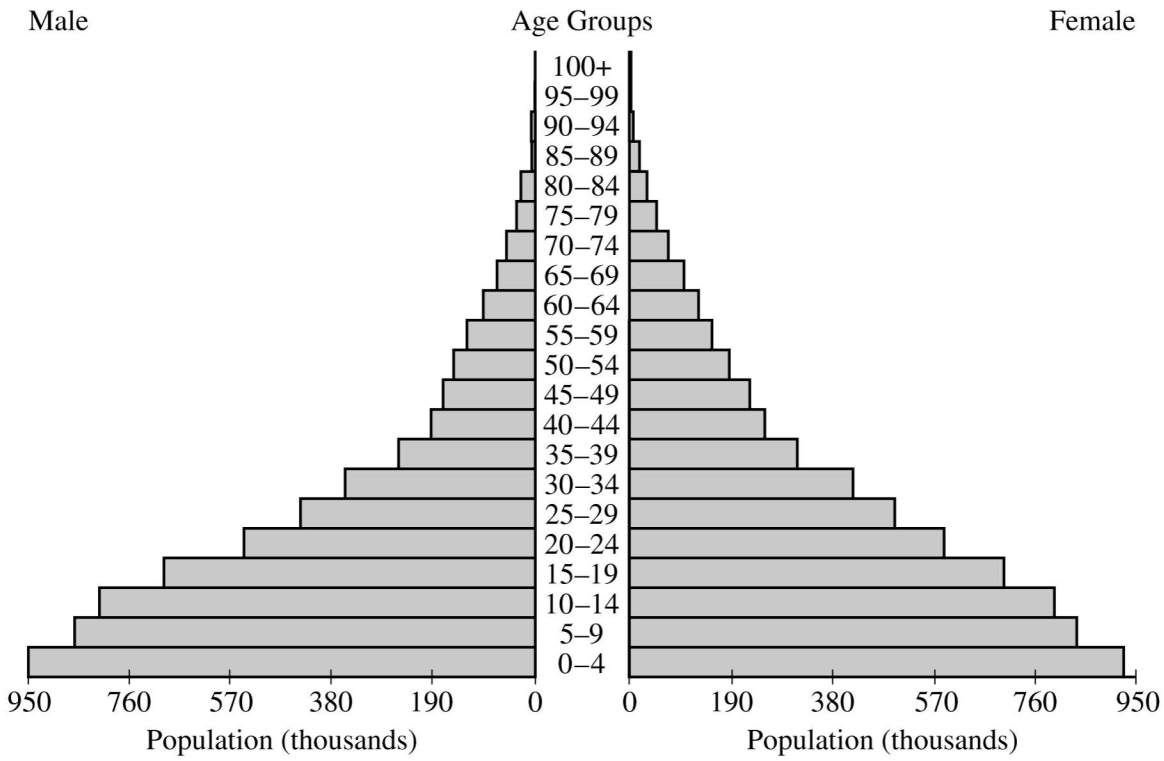
    (A) Installing passive solar energy systems on all available, unshaded rooftop space and positioning them to face south

    (B) Installing active solar energy systems on all available, shaded rooftop space and positioning them to face northeast

    (C) Installing passive solar energy systems on all available, shaded rooftop space and positioning them to face northeast

    (D) Installing active solar energy systems on all available, unshaded rooftop space and positioning them to face south

GO ON TO THE NEXT PAGE.



21. Based on the diagram, this country is likely experiencing

(A) Rapid population growth
(B) Slow population growth
(C) Declining population growth
(D) No net change in population growth

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22. Which of the following is a measure of the biodiversity of an ecosystem?

(A) The total number of individuals of a single animal species
(B) The density of individuals in a hectare
(C) The total number of different plant species
(D) The soil depth at which burrowing insects are located

23. Which of the following is the most abundant gas by volume in the atmosphere?

(A) CO_2
(B) N_2
(C) CH_4
(D) O_2

24. Which of the following best describes a natural process that adds carbon dioxide to the atmosphere?

(A) Plants excrete carbon dioxide during photosynthesis.
(B) Carbon dioxide is released from the interior of Earth during volcanic eruptions.
(C) Deposition of sediments into ocean basins release carbon dioxide from rock.
(D) Burial of dead plants and animals in swamps and bogs allows carbon dioxide to escape to the atmosphere.

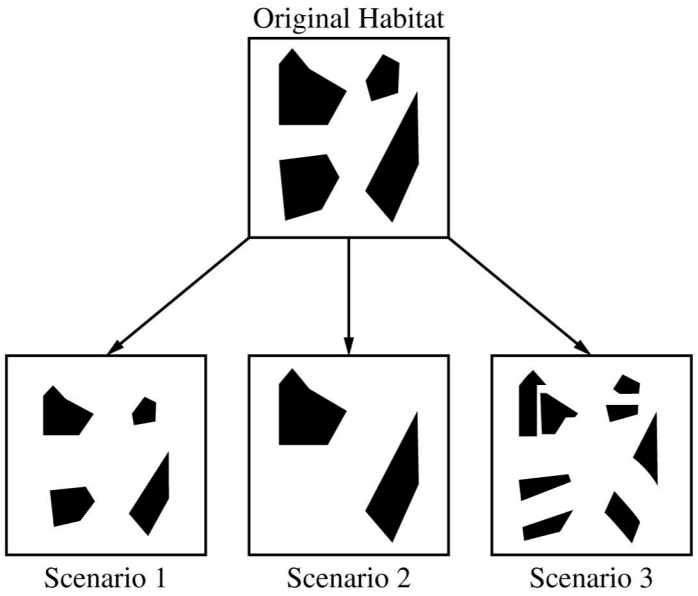
25. An ecologist examining several different ponds discovers that in one pond all the frogs are female. Which of the following most likely led to the all-female population of frogs?

(A) An endocrine disruptor
(B) A carcinogen
(C) Nitrogen fertilizers
(D) Heavy metals

GO ON TO THE NEXT PAGE.

Questions 26 - 29 refer to the diagram below.

The diagram shows how a patch of habitat could possibly be altered.



26. Which of the following correctly identifies the type of habitat change(s) shown within each potential scenario in the diagram?

    (A) Scenario 1 experienced habitat fragmentation, while Scenarios 2 and 3 experienced habitat loss only.

    (B) Scenarios 1 and 2 experienced habitat loss, while Scenarios 3 experienced habitat fragmentation only.

    (C) All scenarios experienced habitat loss, but only Scenario 3 experienced habitat fragmentation.

    (D) All scenarios experienced habitat fragmentation, but only Scenario 2 experienced habitat loss.

27. Which of the following would be most likely to occur in the scenarios that have experienced habitat loss and/or fragmentation in the diagram?

    (A) Increase in territory size of large mammals

    (B) Increase in genetic diversity of native species

    (C) Decrease in the number of specialist species

    (D) Decrease in the abundance of invasive species

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28. Which of the following would be the most likely explanation for the changes shown in Scenario 3 ?

(A) Native species were replanted in the areas, which led to fewer niches.

(B) Roads and electric power lines subdivided the landscape into smaller pieces and decreased the amount of available habitat.

(C) The increased edge-to-interior ratio resulted in habitat fragmentation and the formation of smaller, more manageable parcels of land.

(D) Habitat corridors were built to allow individuals between populations to mate, which helped to prevent inbreeding and reduce the genetic diversity often found in isolated populations.

29. Which of the following is a possible effect of global climate change as illustrated in Scenario 1 ?

(A) Increased sea level would reduce the size of the habitat patches.

(B) Increased carbon dioxide availability spurs plant growth, which would increase habitat size.

(C) Decreased temperatures would cause unsuitable abiotic conditions.

(D) Decreased precipitation would eliminate habitat patches.

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THE EFFECT OF pH ON FROG EMBRYO HATCHING

pH Exposure	Embryos Exposed (n)	Embryos Hatched (n)	Percentage Hatched
pH 6.5	30	0	0
pH 6	30	11	36.7
pH 5.5	30	16	53.3
pH 5	30	20	66.7
pH 4.5	30	27	90
pH 4	30	0	0
pH 3.5	30	0	0

30. Which of the following best describes the frog species' range of tolerance to acidic conditions?

(A) The frogs can tolerate any pH greater than 6.
(B) The frogs can tolerate a pH between 4.5 and 6.
(C) The frogs can tolerate a pH between 3.5 and 5.
(D) The frogs can tolerate any pH less than 4.

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31. Which of the following best describes a supporting ecological service provided by wetlands?

(A) Wetlands serve as a source of aesthetic inspiration for art and literature.
(B) Wetlands provide opportunities for ecotourism, which provides revenue to the local economy.
(C) Wetlands serve as a major reservoir for nitrogen in the nitrogen cycle.
(D) Wetlands provide a habitat for a wide variety of organisms.

32. In which of the following atmospheric layers does most weather occur?

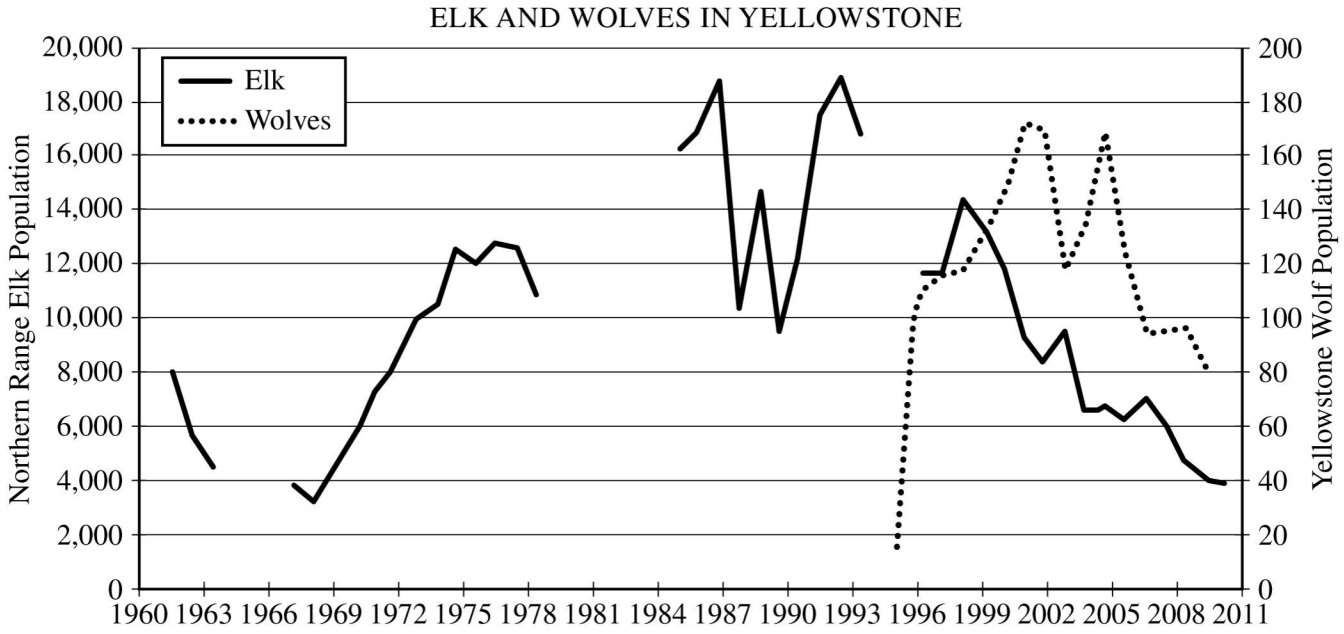
(A) Troposphere
(B) Stratosphere
(C) Mesosphere
(D) Thermosphere

33. Buildings designed to partially heat rooms by passive solar heating rely on

(A) solar cells to generate electricity to power a heater in the room
(B) solar collectors to warm water that is pumped into the room
(C) warm water pumped from underground to warm the room
(D) materials that absorb and store solar energy to warm the room

Questions 34 -36 refer to the graph below.

Wolves were reintroduced into Yellowstone National Park in 1995. In addition to tracking changes in the wolf population, scientists were interested in how the wolves would affect other parts of the Yellowstone ecosystem. In particular, they were interested in changes to the population of elk, the wolves' primary prey. The graph below shows the population size of the wolf and elk populations over time.



34. Based upon the data presented in the graph, which of the following best identifies the highest wolf population size?

    (A) 20
    (B) 120
    (C) 170
    (D) 190

35. Which of the following best describes the change in the elk population since the introduction of wolves into Yellowstone in 1995 ?

    (A) The elk population steadily increased in numbers.
    (B) The elk population steadily decreased in numbers.
    (C) The elk population remained stable, experiencing little changes.
    (D) The elk population reached carrying capacity and experienced overshoot.

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36. Which of the following is a potential disadvantage of reintroducing wolves to Yellowstone?

(A) The wolves are causing a trophic cascade that could further increase the number of beavers and tree species such as willows and aspens.

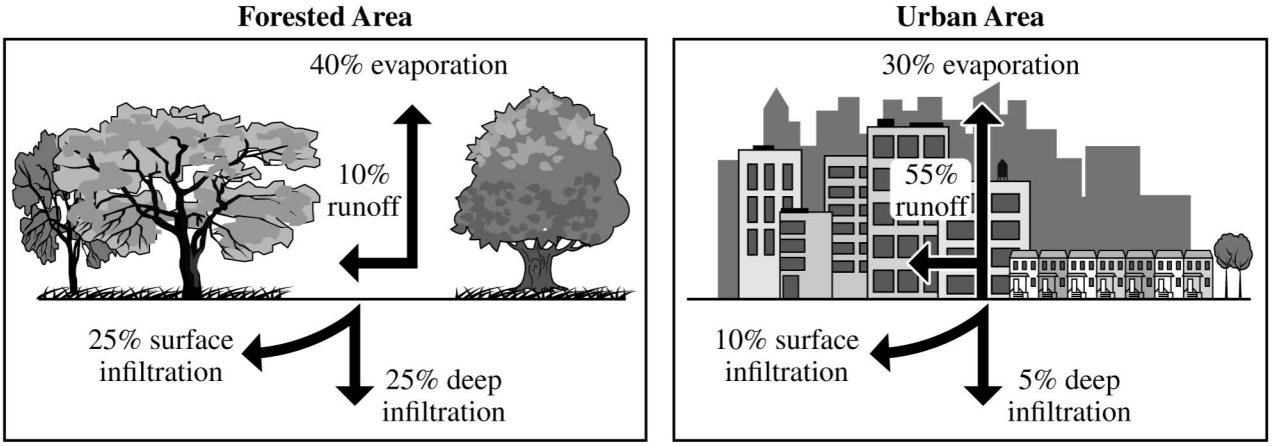
(B) Wolves leaving the park may prey on livestock in grazing land outside the park.

(C) Wolves are extremely fast breeders and may become an invasive species if they get outside the park.

(D) The ecosystem could collapse because wolves were never in Yellowstone before 1995.

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Questions 37 - 39 refer to the diagrams below.



37. Based on the diagrams above, what is the percent change in the amount of runoff in urban areas compared to forested areas?

    (A) 81% decrease
    (B) 60% decrease
    (C) 150% increase
    (D) 450% increase

38. Based on the diagrams above, which of the following best explains how urban runoff could be decreased?

    (A) Decrease the number of trees in urban areas to increase ground infiltration.
    (B) Increase the number of trees to decrease the amount of evapotranspiration.
    (C) Replace traditional pavement with more porous pavement to increase ground infiltration.
    (D) Replace more porous pavement with traditional pavement to decrease the amount of evapotranspiration.

39. Which of the following processes shown in the diagram leads to precipitation?

    (A) Evaporation rate
    (B) Runoff rate
    (C) Surface infiltration rate
    (D) Deep infiltration rate

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40. The spotted lanternfly is a herbivorous insect that is native to Asia and feeds on over 70 species of plants. The feeding behavior of the spotted lanternfly damages plants, and the nymph and adult lanternflies secrete sticky residues that exacerbate the damage to native plant species by promoting mold growth. The spotted lanternfly reproduces once during its lifetime by laying between 30 and 50 eggs, and the eggs hatch after a short amount of time. The range of the spotted lanternfly is increasing because the insects are transported to new environments by the movements of animals and people, and it is now found in many parts of the United States.

Which of the following best describes the spotted lanternfly in the United States?

(A) The spotted lanternfly is a K-selected and invasive species.

(B) The spotted lanternfly is a K-selected and endangered species.

(C) The spotted lanternfly is an r-selected and invasive species.

(D) The spotted lanternfly is an r-selected and endangered species.

41. Which of the following best describes the energy resource used most often for heating and cooking in less developed countries?

(A) Bituminous coal is primarily used because of its relative abundance and high moisture content.

(B) Cogeneration from fuel oil systems is primarily used because it has low up-front costs.

(C) Biomass is the predominant fuel source because it is easily obtained locally.

(D) Natural gas is the most prevalent fuel source because it is readily available and produces few air pollutants.

42. Which of the following correctly explains a positive climate feedback loop found in the Arctic?

(A) Increased melting of permafrost increases Earth's ability to absorb methane gas, which decreases greenhouse warming and decreases the melting of permafrost.

(B) Increased global temperatures lead to decreased sea ice coverage and decreased albedo, which further increases global temperatures.

(C) Increased evaporation and cloud formation decreases the amount of solar energy reaching the surface of Earth, which leads to cooler temperatures at the surface and decreased evaporation and cloud formation.

(D) Increased precipitation increases the size of high albedo snowpack in polar regions, which leads to increased habitat for Arctic organisms such as polar bears.

43. Which of the following is the best method for preventing soil erosion in an agricultural area?

(A) Slash-and-burn agriculture

(B) Integrated pest management

(C) Monocrop farming

(D) Terrace farming

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Questions 44 - 46 refer to the table below.

The following table shows population data for China.

Population Growth Data, China 1994 - 2019

Year	Births per 1,000	Deaths per 1,000
1994	17.6	6.8
2004	11.8	6.3
2014	12.3	7.4
2019	11.9	8.1

44. Using the data from the table, which of the following is the growth rate for China in 2019 ?

(A) 0.38%
(B) 0.49%
(C) 0.60%
(D) 0.68%

45. Which of the following was the doubling time for China's population in 2014 if the growth rate was 0.49 percent?

(A) 1.4 years
(B) 34.3 years
(C) 142.9 years
(D) 3,430 years

46. Which of the following calculation methods would determine the percent change in the crude birth rate from 1994 to 2019 ?

(A) $(17.6 - 11.9) \times 100$
(B) $\dfrac{11.9 - 17.6}{17.6} \times 100$
(C) $\dfrac{17.6 + 11.9}{17.6} \times 100$
(D) $\dfrac{11.9}{17.6} \times 100$

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47. Earth currently rotates on an axis at an angle of 23.5 degrees. If that axis changed to 20 degrees, so that the axis was closer to vertical, which of the following would be expected to occur?

(A) The number of days in a year would be reduced.

(B) Earth would experience increased volcanic activity.

(C) The amount of energy Earth receives from the Sun would increase.

(D) Earth would experience a change in seasonal timing and length.

48. Which of the following accurately describes a benefit of concentrated animal feeding operations (CAFOs) ?

(A) Concentrated animal feeding operations produce a large amount of manure, which is then often held in large manure lagoons.

(B) The animals raised in concentrated animal feeding operations are usually grass-fed and therefore less susceptible to disease.

(C) Concentrated animal feeding operations are efficient and relatively low-cost facilities that help keep consumer costs low.

(D) When animals are kept in large concentrations in a small area, the water quality of local waterways is protected from excess runoff.

49. In addition to volatile organic compounds (VOCs), which of the following components must be present in the atmosphere to create photochemical smog?

(A) NO_x and particulates

(B) Particulates and UV light

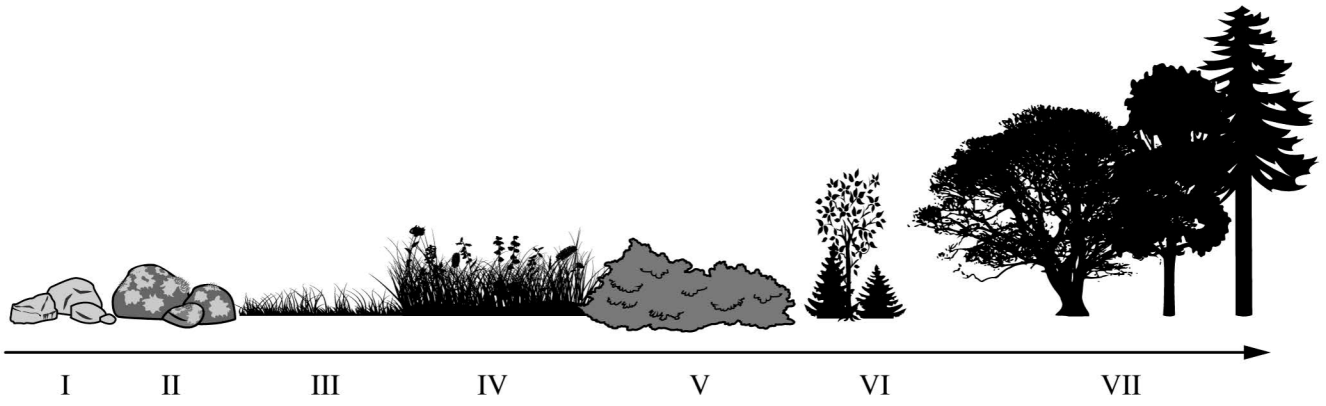
(C) NO_x and UV light

(D) UV light and CO_2

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Questions 50 - 52 refer to the diagram below.

The diagram below shows the change in an ecosystem over time.



50. Which of the following best identifies and describes the process that is illustrated in the diagram above?

    (A) Primary succession, because the result is a mature forest with a variety of shade-intolerant shrubs and grasses
    (B) Primary succession, because the process in the diagram begins with bare rock.
    (C) Secondary succession, because intermediate plant species like grasses and weeds are present
    (D) Secondary succession, because the result is a mature forest with a variety of shade-tolerant trees

51. Based on the diagram above, in which stage are most species present considered pioneer species?

    (A) I
    (B) II
    (C) III
    (D) IV

52. Which of the following best describes the role of moss in the transition to stage III of the process?

    (A) It serves as a soil seed bank in the leaf litter.
    (B) It breaks down rock and adds organic nutrients to the soil.
    (C) It provides shade and reduces surface temperatures.
    (D) It provides habitat for birds and mammals.

GO ON TO THE NEXT PAGE.

Questions 53 - 55 refer to the article below.

Era of 'Biological Annihilation' Is Underway, Scientists Warn

... Thousands of animal species are in precipitous decline, a sign that an irreversible era of mass extinction is underway, new research finds.

...

Dr. Ceballos, a researcher at the Universidad Nacional Autónoma de México, emphasized that he and his co-authors, Paul R. Ehrlich and Rodolfo Dirzo, both professors at Stanford University, ... are using scientific data to back up their assertions that significant population decline and possible mass extinction of species all over the world may be imminent, and that both have been underestimated by many other scientists.

The study's authors looked at reductions in a species' range — a result of factors like habitat degradation, pollution and climate change, among others — and extrapolated from that how many populations have been lost or are in decline ... .

They found that about 30 percent of all land vertebrates ... are experiencing declines and local population losses. In most parts of the world, mammal populations are losing 70 percent of their members because of habitat loss.

...

Dr. Jonathan Losos, a biology professor at Harvard, ... noted that giving precise estimates of wildlife populations was difficult, in part because scientists do not always agree on what defines a population ... .

...

The authors of the paper suggest that previous estimates of global extinction rates have been too low, in part because scientists have been too focused on complete extinction of a species ... .

Scientists estimate that 200 species have gone extinct in the past 100 years; the "normal" extinction rate over the past two million years has been that two species go extinct every 100 years because of evolutionary and other factors.

...

Dr. Ehrlich, who wrote "The Population Bomb," a book that predicted the imminent collapse of humanity because of overpopulation, and Dr. Ceballos said that habitat destruction ... and pollution were the primary culprits, but that climate change exacerbates both problems. Accelerating deforestation and rising carbon pollution are likely to make climate change worse, which could have disastrous consequences for the ability of many species to survive on earth.

Dr. Ceballos struck a slightly more hopeful tone, adding that some species have been able to rebound when some of these pressures are taken away. ...

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53. Which of the following statements best identifies the author's claim about modern species?

(A) Reduction in range size is an indicator that populations of many species are declining.

(B) Ranges of most species are expanding toward the poles because of climate change.

(C) Populations of plants are increasing because of excess CO_2 in the atmosphere.

(D) While most organisms are declining in population size, most mammal populations are actually increasing.

54. Based on the passage, which of the following describes the author's perspective on why historical extinction rates were lower than present-day rates?

(A) Scientists believe that humans are responsible for the first major mass extinction.

(B) Previous research focused only on complete extinctions and did not collect data on imminent extinctions.

(C) Habitat destruction occurred only in regions with low biodiversity until the last few decades.

(D) Scientists disagree on how to define "extinction."

55. Which of the following pieces of evidence presented in the article suggests that extinction rates may continue to increase?

(A) Populations are unable to rebound even when environmental stressors are removed.

(B) Mammal populations are declining faster than other vertebrate groups.

(C) Climate change will exacerbate the primary causes of population decline.

(D) Species ranges are expanding as pollution increases in less-developed countries.

56. Which of the following would most likely neutralize the effect of acid rain on bodies of water, based on the composition of soils and bedrock in the region?

(A) An area downwind of a coal-burning electrical plant
(B) A valley that is frequently shrouded in fog
(C) A forest underlain by limestone
(D) An open plain underlain by granite

57. Which of the following best describes a density-independent factor that controls population size?

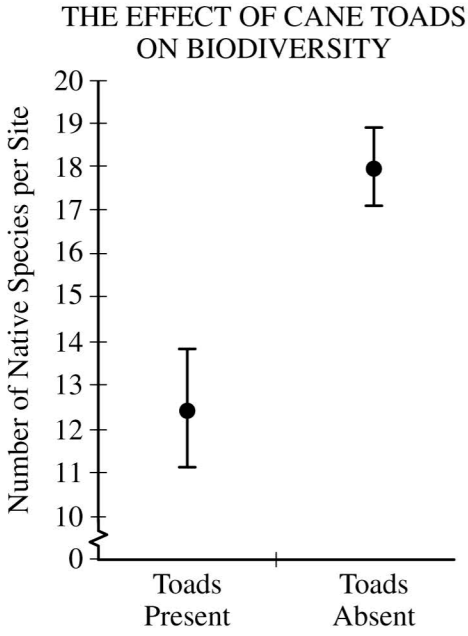
(A) Competition for resources like food and water
(B) Infectious disease transmission
(C) Occurrences of droughts and flooding
(D) Reduced availability of habitat

58. Scientists want to investigate whether the increased concentration of carbon dioxide in the ocean affects fish survival. Scientists suspect immature fish larvae may be most affected by increased carbon dioxide concentrations. Which of the following best identifies a testable hypothesis for the investigation?

(A) The decreasing pH of the ocean water will decrease the survivorship of fish.
(B) The decreasing temperature of the ocean water will increase the survivorship of fish larvae.
(C) There will be a greater percentage of fish larvae that survive than mature fish that survive.
(D) The increasing carbon dioxide concentrations will increase the density of adult fish skeletons.

GO ON TO THE NEXT PAGE.

59. Cane toads are an invasive species that were introduced to Australian ecosystems. Researchers studying cane toads hypothesize that cane toads are negatively affecting native species. The researchers observed different locations with and without cane toads and collected the data that are presented in the following graph.



Which of the following best interprets the results in the graph in relation to the given hypothesis?

(A) The results support the researchers' hypothesis because there is a greater biodiversity at sites with cane toads.

(B) The results support the researchers' hypothesis because there is a greater biodiversity at sites without cane toads.

(C) The results do not support the researchers' hypothesis because there is less biodiversity at sites with cane toads.

(D) The results do not support the researchers' hypothesis because there is less biodiversity at sites without cane toads.

60. The table below shows the oral LD50 values for various household substances.

Substance	Oral LD50 (mg / kg)
Aspirin	1,000
Table salt	3,320
Antifreeze	460
Vinegar	3,300

Based on the LD50 values, which of the following best describes the toxicity level of the household substances shown in the table?

(A) Aspirin is less toxic than vinegar.

(B) Table salt is more toxic than vinegar.

(C) Antifreeze is more toxic than aspirin.

(D) Table salt is the most toxic substance in the table.

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61. Silver carp were introduced in the southeastern United States in the 1970s from their native habitat of China to control algal blooms that were occurring at aquaculture facilities and sewage lagoons. Silver carp escaped from captivity shortly after their introduction and are currently found as far north as North Dakota and Minnesota. Which of the following describes an unintended, negative consequence of the introduction of silver carp into the United States?

(A) Silver carp decreased the amount of algae and aquatic vegetation in ponds and lagoons in the southern United States.

(B) Silver carp populations in the United States are likely to become endangered as a result of limited prey resources in the new environment.

(C) Silver carp became a keystone species and created more biodiversity in lakes and rivers in the southeastern United States.

(D) Silver carp became an invasive species in the United States because their numbers were not being controlled by natural predators.

62. A farm is experiencing extensive crop loss due to high rains causing overly saturated soils. Which of the following approaches would best help the farmer alleviate the problem?

(A) Fertilizing the area with manure to eliminate the need for inorganic chemical fertilizers

(B) Amending the soil with clay to increase the water-holding capacity of the soil

(C) Amending the soil with sand to increase the permeability of the soil

(D) Using contour plowing to decrease soil erosion

63. Which of the following best describes a potential unintended negative consequence of implementing measures to control acid deposition?

(A) A reduction in environmental lead, leading to decreased negative health effects in humans and wildlife

(B) A reduction in sulfur for crops as a result of less acidic rainfall, leading to an increased need for sulfur supplements

(C) A reduction in mortality rates in freshwater aquatic organisms from an increase in pH of the water

(D) A reduction in acid mine drainage, resulting from a reduced need for nuclear fuel and uranium mining

64. Scientists are interested in measuring the effect of pollution on the water quality of a stream. They will use observations of various bottom-dwelling insects, or macroinvertebrates, collected in the stream as indicators of the physical, chemical, and biological conditions within the stream. Which of the following best describes why macroinvertebrate sampling can be used to assess the overall health of a stream?

(A) Macroinvertebrates live in an aquatic ecosystem for a long enough time to show the chronic effects of pollutants, and many tend to remain in the same area throughout their life span.

(B) Macroinvertebrates migrate long distances to feed or reproduce, and they have a low tolerance to pollutants.

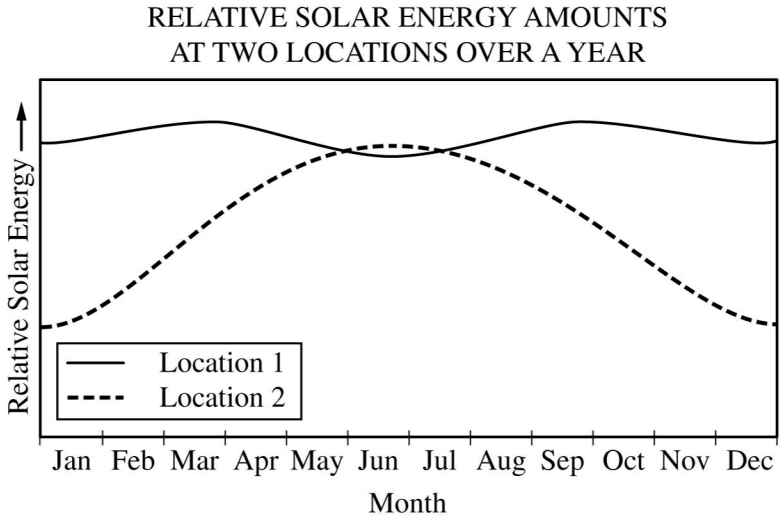
(C) Macroinvertebrates are top predators, so they are often used in determining whether toxins will bioaccumulate or biomagnify in an aquatic environment.

(D) Macroinvertebrates can be collected to evaluate the effect of various test parameters such as dissolved oxygen, nitrites, and pH at the time that the sample was taken.

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Questions 65 - 67 refer to the graph below.

The graph shows the relative solar energy received at local noon each day of the year at two different locations.



65. Based on the graph, which of the following can be concluded about the latitudes of the two locations?

    (A) Both locations are at the same latitude.
    (B) Location 1 is close to the equator, and Location 2 is in the Northern Hemisphere.
    (C) Location 1 is in the Northern Hemisphere, and Location 2 is in the Southern Hemisphere.
    (D) Location 1 is in the Southern Hemisphere, and Location 2 is close to the equator.

66. Assuming all other variables are constant, which of the following is the most likely conclusion about the greatest potential for gross primary productivity that can be supported by data in the graph?

    (A) Gross primary productivity is the same for both locations all year.
    (B) Gross primary productivity in Location 2 is greater than that in Location 1 in December.
    (C) Gross primary productivity in Location 1 is greater than that in Location 2 in March.
    (D) Gross primary productivity in Location 2 is greater than that in Location 1 in September.

67. Location 1 is most likely located in which of the following terrestrial biomes?

    (A) Taiga
    (B) Tundra
    (C) Tropical rain forest
    (D) Temperate grassland

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68. The table below shows fish harvest data from United States commercial fisheries in 2011, 2012, and 2013.

	2011	2012	2013
Total Fish Landings	6.1 billion pounds	6.0 billion pounds	6.1 billion pounds
Bycatch	714.2 million pounds	601.7 million pounds	689.1 million pounds

Fish landings are defined as the total catch of marine fish that are brought into ports for sale. Bycatch refers to the unwanted fish and other marine organisms that are caught during commercial fishing operations, but are not harvested or sold. Which of the following methods would you use to calculate the percent of the total catch of all fish in 2012 that was bycatch?

(A) $\dfrac{6.017 \times 10^8}{6 \times 10^9 + 6.017 \times 10^8}$

(B) $\dfrac{6 \times 10^9}{6 \times 10^9 + 6.017 \times 10^8}$

(C) $\dfrac{6.017 \times 10^8}{6 \times 10^9} \times 100$

(D) $\dfrac{6.017 \times 10^8}{6 \times 10^9 + 6.017 \times 10^8} \times 100$

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69. Integrated pest management (IPM) uses a variety of techniques to reduce pest populations while reducing the economic damage caused by pests.

Which of the following techniques is a mechanical IPM method for reducing pests?

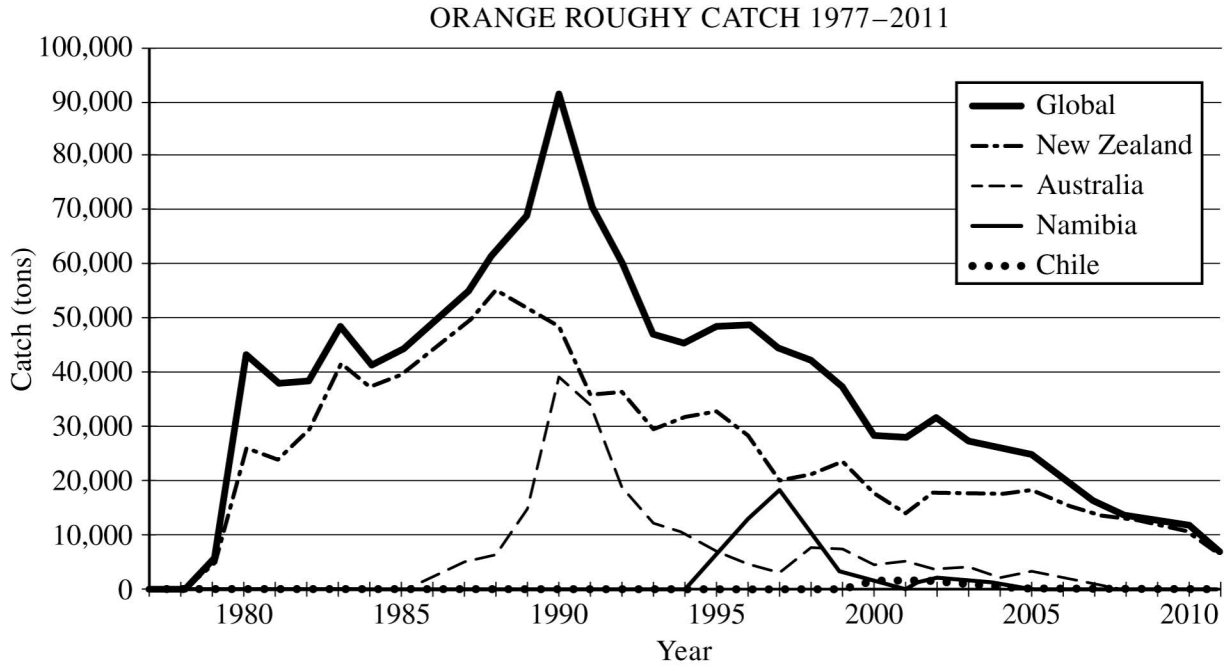
(A) The use of a predator or parasites to keep the population size of pest species low
(B) The use of screens or traps to prevent pests from entering the crop area
(C) The use of monocultures to keep the population size of pest species low
(D) The use of pesticides sprayed on fields to kill pests and keep population sizes low

70. Which of the following best describes one way the Clean Air Act helped reduce air pollution?

(A) Implemented a program to manage hazardous and nonhazardous wastes
(B) Proposed incentives for countries to reduce carbon emissions
(C) Created a fund to aid developing countries in reducing ozone-depleting emissions
(D) Introduced regulatory measures to control the amount of lead in fuels

71. Which of the following best explains why the lower portion of the troposphere is warmer than the upper portion?

(A) The lower portion of the troposphere is separated by the ozone layer from the upper portion, so the lower portion absorbs more sunlight, increasing the temperature.
(B) The air in the lower portion of the troposphere is less dense than the air in the upper portion, leading to a higher temperature in the lower portion.
(C) The surface of Earth absorbs sunlight, heating the lower portion of the troposphere more than the upper part.
(D) The troposphere is the highest layer of the atmosphere, so the lower portion is warmed more than the upper part by rising air.



72. The graph shows the worldwide catch of orange roughy, a type of wild caught fish, in tons, from 1977 to 2011.

Based on the data in the graph, which of the following fishing practice solutions would best promote the sustainability of the orange roughy population?

(A) A decrease in the minimum size limit of fish that can be caught
(B) An increase in subsidies to fishermen that catch orange roughy
(C) Establishment of quotas on the number of orange roughy caught
(D) Protection of the orange roughy predator through legislation

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73. A local citizen science group is monitoring the water quality of a nearby lake. They gather water samples once a week on Wednesday between the hours of 7 A.M. and 9 A.M. from the same location. One day in August they were unable to sample within that time frame and collected the sample at 3 P.M.

How might this modification to the sampling procedure affect the results?

(A) Water sampled later in the day may be warmer and therefore have lower dissolved oxygen levels.

(B) Water sampled later in the day may be warmer and therefore have higher dissolved oxygen levels.

(C) Water sampled later in the day may have decreased macroinvertebrate respiration and therefore lower dissolved oxygen levels.

(D) Water sampled later in the day may have increased macroinvertebrate respiration and therefore higher dissolved oxygen levels.

74. Which of the following would be the best way to mitigate deforestation?

(A) Grow more diverse timber products to increase economic value in an area.

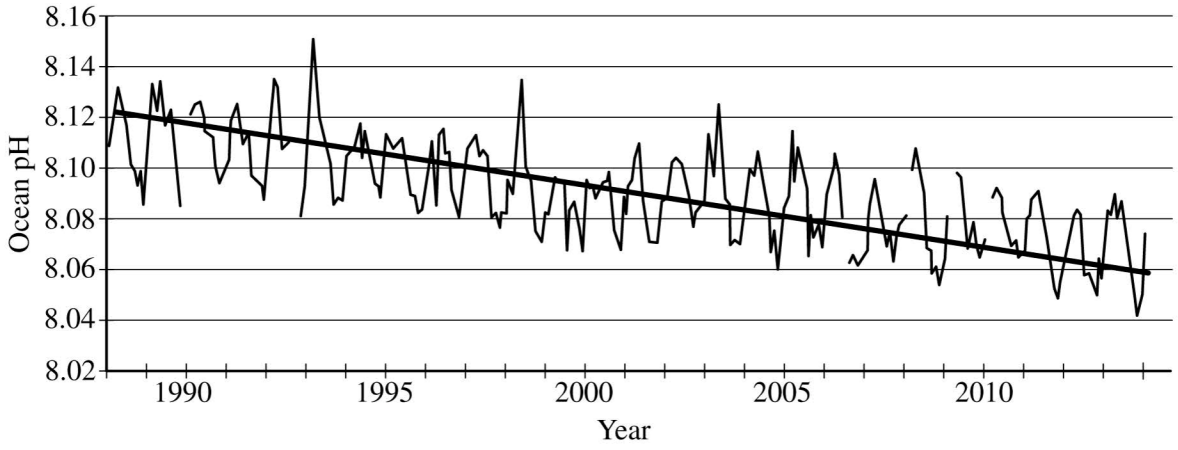
(B) Stimulate intensive agricultural production of native vegetation close to villages.

(C) Employ clear cutting harvest techniques that are more sustainable.

(D) Replant and protect trees in areas that have been previously cleared.

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CALCULATED MEAN pH CHANGES IN THE OCEAN, 1988–2014



75. Which of the following best explains an anthropogenic cause of the trend illustrated on the graph?

(A) Increased atmospheric CO_2 concentrations from burning of fossil fuels and vehicle emissions are contributing to ocean acidification.

(B) Increased atmospheric CO_2 concentrations from volcanic eruptions and cellular respiration are contributing to coral bleaching.

(C) Increased atmospheric NO_x concentrations from fertilizers and livestock operations are contributing to a decrease in acid deposition in the ocean.

(D) Increased atmospheric NO_x concentrations from decomposition in landfills is contributing to eutrophication.

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76. Industrial scrubbers and electrostatic precipitators collect enormous amounts of particulate matter (coal ash) at coal-burning power plants. Which of the following best describes an environmental disadvantage of using industrial scrubbers and electrostatic precipitators for pollution abatement?

(A) Coal ash contains toxic levels of several different pollutants, so when it is collected and stored long-term in coal ash ponds, there is increased risk of exposure to toxic metals.

(B) Coal ash is highly flammable, and it is very hazardous to ship the materials to hazardous waste landfills.

(C) Industrial scrubbers and electrostatic precipitators cannot remove fine particles like dust and smoke from the waste, so a secondary measure must be used.

(D) Industrial scrubbers and electrostatic precipitators are very costly to install and increase the cost of operating coal-burning power plants, leading to increased costs for consumers.

77. A sanitary landfill with a surface area of 6000 m^2 receives a yearly rainfall amount of 300 mm. About 20 percent of this precipitation is runoff and does not infiltrate the surface. A leachate collection system, which is installed underneath the landfill, is 90 percent effective at collecting and treating any water that infiltrates the surface of the landfill.

Assuming consistent yearly rainfall amounts, what is the volume of leachate, in m^3, that the landfill will be able to treat per year?

(A) 1,800 m^3

(B) 1,296 m^3

(C) 360 m^3

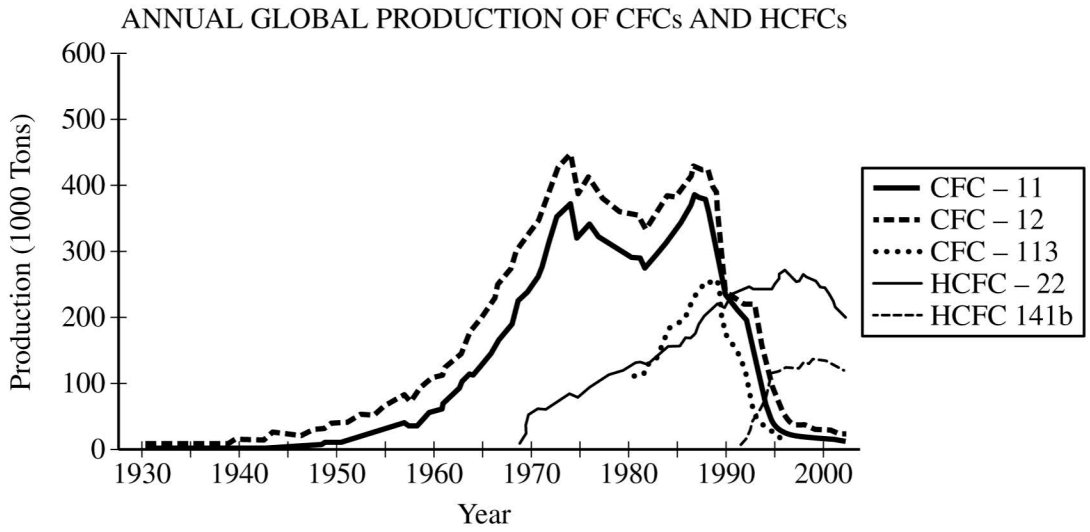
(D) 324 m^3

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Questions 78 and 79 refer to the graph below.



78. In 1978, the United States banned the use of CFCs in aerosols. Based on the data in the graph, which of the following best explains the effect of this ban as a solution to decrease global CFC production?

(A) The ban on CFCs led to a decrease of CFC-11 and CFC-12 production by more than 15% between 1978 and 1980, which supports the ban as an effective solution to reduce global CFC production.

(B) The ban on CFCs in aerosols led to an increase in CFC-113 production for use in refrigerants and air conditioners in the United States, which led to a 10% overall increase in global CFC production between 1970 and 1980.

(C) The ban on CFCs also led to a decrease in HCFC production beginning in 1980, reducing the reliance on chlorinated chemicals used in industrial processes and greatly reducing stratospheric ozone depletion.

(D) The ban on CFCs in aerosols in the United States was not effective on a global scale because it led to an increase in reports of skin cancer and cataracts in patients in the Southern Hemisphere from 1970 to 2000.

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79. Which of the following statements best uses the data to support the claim that the Montreal Protocol was an effective solution for a global problem?

(A) The Montreal Protocol reduced stratospheric ozone depletion by increasing the reliance on CFCs in industrial processes. Based on the graph, the increase in global CFC production from 1960 to 1970 demonstrates the success of the protocol by substituting ozone-depleting substances with CFCs.

(B) The Montreal Protocol was passed in 1970 to increase the production of HCFCs, which led to decreased reliance on CFCs. Based on the graph, HCFC-22 production increased steadily from 1980 to 1990 and HCFC-141b increased from 1990 to 2000.

(C) The Montreal Protocol led to a dramatic reduction in CFC production globally after 1987, which greatly reduced the concentration of chlorinated hydrocarbons present in the stratosphere and decreased the breakdown of stratospheric ozone. Based on the graph, the annual production of CFCs decreased significantly in the late 1980s to almost 0 tons by 2000.

(D) The Montreal Protocol monitored the production and sale of CFCs and HCFCs in the late 1990s to decrease tropospheric ozone pollution and photochemical smog. Based on the graph, CFCs and HCFCs leveled off at 100,000 tons produced in 2000.

80. Bats use echolocation to find prey by emitting high-pitched bursts of sound and analyzing the reflection. Scientists studying a population of bats in a forest observed that their population size had declined in the years following the completion of a nearby highway.

Based on the information above, which of the following best explains how noise pollution from the highway has affected the size of the bat population?

(A) The highway noise is decreasing the bats' echolocation, allowing them to catch more prey each night.

(B) The highway noise is interfering with bats' echolocation, preventing them from successfully locating and catching prey as they fly.

(C) The highway noise is producing sound waves that disrupt air flow, preventing the bats from flying at night.

(D) The highway noise is attracting more bats to the forest, causing an increase in intraspecies competition.

GO ON TO THE NEXT PAGE.

END OF SECTION I

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION.

DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.

MAKE SURE YOU HAVE DONE THE FOLLOWING:

- **PLACED YOUR AP ID LABEL ON YOUR ANSWER SHEET**
- **WRITTEN AND GRIDDED YOUR AP ID CORRECTLY ON YOUR ANSWER SHEET**
- **TAKEN THE AP EXAM LABEL FROM THE FRONT OF THIS BOOKLET AND PLACED IT ON YOUR ANSWER SHEET**

AP® Environmental Science Exam

SECTION II: Free Response

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

At a Glance

Total Time
1 hour and 10 minutes
Number of Questions
3
Percent of Total Score
40%
Writing Instrument
Pen with black or dark blue ink
Electronic Device
Calculator allowed
Weight
The questions are weighted equally, but the parts of a question are not necessarily given equal weight.

Instructions

The questions for Section II are printed in this booklet. You may use the blank page 3 to organize your answers and for scratch work, but you must write your answers on the lined pages provided for each question.

Each answer should be organized, comprehensive, and in prose form; outline form is not acceptable. Do not spend time restating the questions or providing more than the number of examples called for. For instance, if a question calls for two examples, you can earn credit only for the first two examples you provide. Diagrams may be used to supplement discussion, but diagrams alone will not suffice.

Write clearly and legibly. Do not skip lines. Cross out any errors you make; crossed-out work will not be scored.

Manage your time carefully. You may proceed freely from one question to the next. You may review your responses if you finish before the end of the exam is announced.

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ENVIRONMENTAL SCIENCE

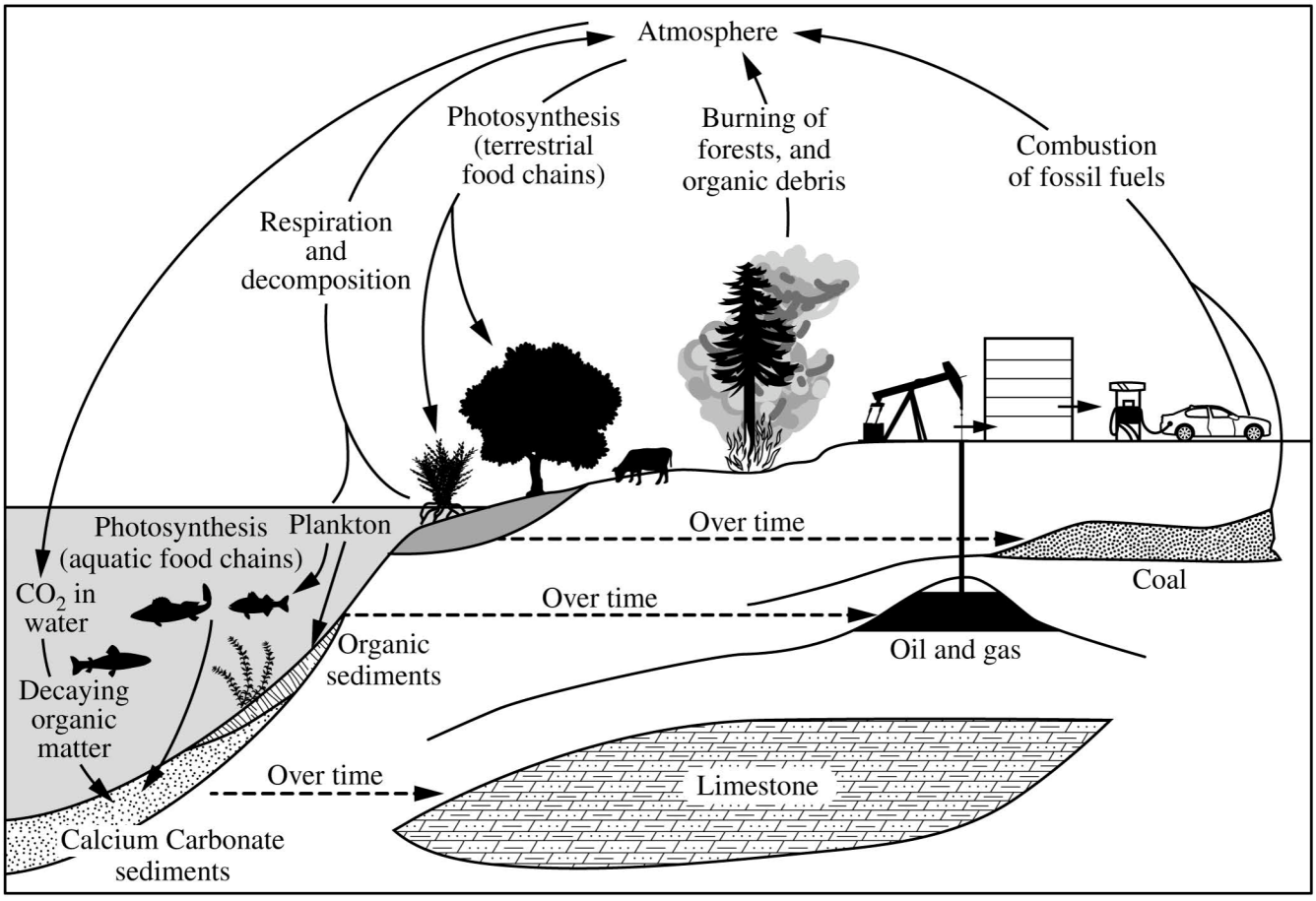
SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers on the pages following the questions in this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. (a) The diagram below shows the cycling of carbon.



(i) **Identify** a process shown in the diagram that removes carbon from the atmosphere.

(ii) **Identify** a process shown in the diagram that sequesters carbon from the atmosphere for a geological period of time.

GO ON TO THE NEXT PAGE.

(iii) Based on the diagram, **explain** how the combustion of fossil fuels has led to an imbalance in the carbon cycle.

(iv) **Explain** the role of decomposition in the carbon cycle.

(b) Scientists are interested in researching how carbon dioxide in the oceans is affecting its pH. They design a laboratory experiment in which they inject different concentrations of carbon dioxide into saltwater tanks containing calcium carbonate shells. The tanks were kept at the same, constant temperature. After several days, the scientists measured the pH of the saltwater tanks and observed its effects on the calcium carbonate shells.

(i) **Identify** the independent variable in this experiment.

(ii) **Describe** a control group that could be used in this experiment.

(iii) **Explain** the effect of carbon dioxide on the pH of the oceans.

(iv) **Describe** the effect of water temperature on the amount of dissolved gases in water.

(v) **Describe** how the results of the experiment would change if the temperature of the tanks was decreased.

(vi) **Describe** how a decrease in ocean pH can affect marine organisms.

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ANSWER PAGE FOR QUESTION 1

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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2. The waste generated by humans is both an environmental and human health concern.

(a) Many countries now use centralized sewage treatment plants to treat the wastewater from houses and businesses.

(i) **Describe** a main goal of primary treatment in a modern sewage treatment plant.

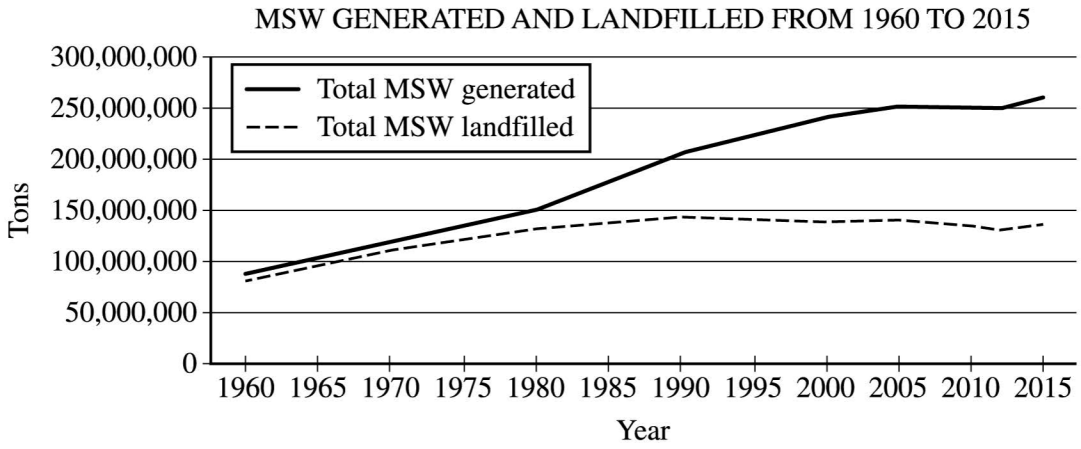
(ii) **Describe** a main goal of secondary treatment in a modern sewage treatment plant.

(iii) Many sewage treatment plants use tertiary treatment as the final step in wastewater treatment. **Describe** one advantage of this process.

(iv) If a sewage treatment plant malfunctions or if low-income areas lack sanitary waste disposal, raw sewage can be introduced into surface waterways. **Describe** one potential environmental problem or one potential human health problem that can result from the presence of raw sewage in surface waters.

(v) **Identify** one water parameter that could be measured to determine whether raw sewage is present in surface waterways.

(b) The United States Environmental Protection Agency (EPA) refers to the trash or garbage that can be placed in landfills (landfilled) as municipal solid waste (MSW). MSW can include such items as bottles, cardboard boxes, food, grass clippings, furniture, tires, computers, and appliances. The total MSW generated and the total MSW landfilled from 1960 to 2015 in the United States are shown in the graph below.



(i) **Describe** the trend in total MSW generated from 1960 to 2015.

(ii) **Compare** the trends in the total MSW generated and the total MSW landfilled between 1990 and 2000.

(iii) **Explain** a probable reason for the trend in the total MSW landfilled described in (b)(ii).

(c) One environmental problem in landfills is that organic materials such as food scraps and yard waste can decompose and produce methane over time. Methane is flammable and can be very dangerous in large concentrations.

(i) **Propose** a solution to reduce the risk of flammable methane from concentrating in landfills.

(ii) **Justify** your solution proposed in (c)(i) by explaining an additional benefit to the solution besides reducing the amount of flammable methane concentrating in the landfill.

GO ON TO THE NEXT PAGE.

ANSWER PAGE FOR QUESTION 2

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

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3. (a) Preserving high-quality agricultural land is important so that countries can grow enough food to feed their populations.

(i) **Describe** one agricultural practice that can lead to the degradation of agricultural land.

(ii) **Describe** a potential solution or technique that can prevent or reduce degradation of agricultural land.

(b) A less developed country with a rapidly expanding urban population is concerned that its growing urban population will eventually expand to a level where there would not be enough land to grow the food it needs to support its population.

(i) Excluding importing food, **propose** a solution to address the concerns of reduced land on which to grow food.

(ii) For your solution in (b)(i), **explain** an additional potential advantage of the solution.

(c) A table for the population size in the country is shown below.

Population Size from 2009 to 2017

Year	Population Size (millions)
2009	2.7
2010	2.8
2011	3.0
2012	3.3
2013	3.6
2014	3.9
2015	4.2
2016	4.4
2017	4.6

(i) Based on the table, **calculate** the percent change of the population size in this country between 2009 and 2017. **Show** your work.

(d) An average person in the country needs 2,450 kilocalories (kcal) / day of food to meet their full nutritional needs. The average number of kcal per hectare (ha) produced from available food in the country is 15,737,000 kcal / ha.

(i) **Calculate** the amount of land that would be needed to produce enough kilocalories to feed a person for one year in this developing country. **Show** your work.

(ii) **Calculate** how much land would have been needed to feed the population of this country in 2017. **Show** your work.

GO ON TO THE NEXT PAGE.

ANSWER PAGE FOR QUESTION 3

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3

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STOP

END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET. MAKE SURE YOU HAVE DONE THE FOLLOWING:

- COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET
- CHECKED THAT YOUR AP ID LABEL IS IN THE BOX ON THE FRONT COVER

Notes on the AP Environmental Science Practice Exam

Multiple-Choice Section

Course Framework Alignment and Rationales

Question 1

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ENG-3.G: Describe the use of nuclear energy in power generation.	Nuclear Power
(A)	Incorrect. Solar energy is a renewable source of energy since it converts energy from the Sun, which is an unlimited resource, into thermal or electrical energy.		
(B)	Incorrect. Wind energy is a renewable source of energy since it relies on the kinetic energy from wind currents, which are an unlimited resource.		
(C)	Incorrect. Geothermal energy is a renewable source of energy since it relies on the heat beneath Earth's surface, which is an unlimited resource.		
(D)	**Correct.** Nuclear energy is considered a nonrenewable source of energy since it relies on the fission of radioactive **uranium**-235, which is a limited resource.		

Question 2

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ENG-3.N: Describe the use of geothermal energy in power generation.	Geothermal Energy
(A)	Incorrect. Solar energy uses energy from the Sun for power generation.		
(B)	Incorrect. Wind energy harnesses the kinetic energy of wind to turn large wind turbines for power generation.		
(C)	**Correct.** Geothermal energy relies on heat from Earth's interior to heat water that becomes steam. This steam is then used to power electric generators.		
(D)	Incorrect. Nuclear energy relies on nuclear fission of radioactive particles, which releases a large amount of heat. This heat is used to generate steam, which powers electric generators.		

Question 3

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ENG-3.J: Describe the use of solar energy in power generation.	Solar Energy
(A)	**Correct.** One form of solar energy generation uses PV cells to capture energy from the Sun to generate a flow of electrons.		
(B)	Incorrect. Wind energy harnesses the kinetic energy of wind to turn large wind turbines for power generation. Photovoltaic cells do not generate electricity from wind energy.		
(C)	Incorrect. Geothermal energy relies on heat from Earth's interior to warm water that becomes steam, which is then used to power electric generators. Photovoltaic cells do not generate electricity from geothermal energy.		
(D)	Incorrect. Nuclear energy relies on nuclear fission of radioactive particles, which releases a large amount of heat. This heat is used to generate steam, which powers electric generators. Photovoltaic cells do not generate electricity from nuclear energy.		

Question 4

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually. 5.C: Explain patterns and trends in data to draw conclusions.		ERT-3.C: Explain survivorship curves.	Survivorship Curves
(A)	**Correct.** K-selected species are at carrying capacity and produce fewer young that are cared for and have longer life spans.		
(B)	Incorrect. The initial dip in survivorship does not best represent a K-selected species. This line has some characteristics of both K-selected and r-selected species.		
(C)	Incorrect. A constant mortality rate does not reflect r- or K-selected species.		
(D)	Incorrect. This curve reflects an r-selected species with no parental care of offspring and a low number surviving to adulthood.		

Question 5

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually. 5.C: Explain patterns and trends in data to draw conclusions.		ERT-3.C: Explain survivorship curves.	Survivorship Curves
(A)	Incorrect. Type I survivorship/K-selected species have fewer offspring and also provide care, which leads to a low death rate in early/middle life. This does not show a species that has many offspring with few survivors.		
(B)	Incorrect. The leveling out of the graph in early/middle life indicates parental care and does not reflect a plant that relies on overproduction of offspring with low survivorship to adulthood.		
(C)	Incorrect. The dandelion does not experience a consistent mortality rate, as this curve indicates.		
(D)	**Correct.** The high early mortality rate is consistent with organisms that have many offspring and provide little parental care, like the r-selected dandelion.		

Question 6

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually. 5.C: Explain patterns and trends in data to draw conclusions.		ERT-3.C: Explain survivorship curves.	Survivorship Curves
(A)	Incorrect. Type I survivorship/K-selected species have fewer offspring and also provide parental care, which leads to a low death rate in early/middle life.		
(B)	Incorrect. Despite the early, low-percentage mortality event, the leveling out of the graph in early/middle life indicates parental care and leads to a low death rate in early/middle life.		
(C)	**Correct.** A Type II survivorship curve is indicated as a straight line with a constant slope that decreases over time toward zero. This is typical of organisms that have a constant survivor probability, such as some species of birds and lizards.		
(D)	Incorrect. The high early mortality rate is consistent with organisms that have many offspring and provide little parental care, as displayed in this Type III curve.		

Question 7

Skill	Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.	ENG-3.L: Describe the use of hydroelectricity in power generation.	Hydroelectric Power

(A)	Incorrect. This location refers to the Great Lakes of the United States, which is not the location of the world's largest hydroelectric dam. The world's largest hydroelectric dam is located in China.
(B)	Incorrect. This location refers to the Mid-Atlantic Ridge, which spans the entire length of the Atlantic Ocean and is a result of a divergent plate boundary. This allows for the use of geothermal energy in Iceland.
(C)	**Correct.** In 2012, the Three Gorges Dam in China became the largest hydroelectric dam in the world, replacing the Itaipú Hydroelectric Dam in Brazil and Paraguay.
(D)	Incorrect. This is not the location of the world's largest hydroelectric dam. This location refers to the Fukushima nuclear power plant and surrounding areas that were devastated from the tsunami generated by the 2011 9.0 magnitude earthquake. The world's largest hydroelectric dam is located in China.

Question 8

Skill	Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.	ERT-4.A: Describe the geological changes and events that occur at convergent, divergent, and transform plate boundaries.	Plate Tectonics

(A)	Incorrect. This location refers to the Great Lakes in the United States. This area is not on or near a convergent boundary nor experiences large magnitude earthquakes.
(B)	Incorrect. This location refers to the Mid-Atlantic Ridge, which is a divergent plate boundary, not a subduction zone. Earthquakes generally occur less frequently and with lower magnitudes at divergent plate boundaries than at convergent plate boundaries.
(C)	Incorrect. This location refers to an area of China where the world's largest hydroelectric dam is located. This area of China is located within the Eurasian Plate and is not near a plate boundary.
(D)	**Correct.** The Fukushima nuclear power plant and the surrounding area were devastated from the tsunami generated by a 9.0 magnitude earthquake in 2011. The earthquake took place at the subduction zone where the Pacific Plate subducts under the Eurasian Plate off the coast of Japan.

Question 9

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		ENG-3.N: Describe the use of geothermal energy in power generation.	Geothermal Energy
(A)	Incorrect. This location refers to the Great Lakes in the United States. This area is not located near a large divergent plate boundary nor uses geothermal energy as its main energy source.		
(B)	**Correct.** The Mid-Atlantic Ridge spans the entire length of the Atlantic Ocean and splits the island of Iceland into two different plates. The close proximity to magma allows Iceland to use geothermal energy, almost exclusively, for energy.		
(C)	Incorrect. This location refers to an area of China where the world's largest hydroelectric dam is located. This area of China is located within the Eurasian Plate and is not near a plate boundary.		
(D)	Incorrect. This location refers to the Fukushima nuclear power plant in Japan. This area is located near a subduction zone, not a divergent plate boundary.		

Question 10

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		EIN-2.E: Describe different methods of irrigation. EIN-2.F: Describe the benefits and drawbacks of different methods of irrigation.	Irrigation Methods
(A)	**Correct.** Drip irrigation uses perforated hoses with individual irrigation lines and is very efficient.		
(B)	Incorrect. Flood irrigation does not use individual irrigation lines; it involves flooding a field with water.		
(C)	Incorrect. Furrow irrigation uses a series of trenches between crops in a field and gravity allows water to seep into the soil.		
(D)	Incorrect. Spray irrigation uses large sprinkler systems that roll back and forth across a field or rotate around a center pivot.		

Question 11

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		EIN-2.E: Describe different methods of irrigation. EIN-2.F: Describe the benefits and drawbacks of different methods of irrigation.	Irrigation Methods
(A)	Incorrect. Drip irrigation allows water to drip slowly to the roots of the plants either from above the soil or buried just beneath the surface, placing water directly into the root zone, not spraying it from sprinklers.		
(B)	Incorrect. Flood irrigation uses a ditch or pipe to allow water to flow directly over the ground and to the crops.		
(C)	Incorrect. Furrow irrigation uses small channels in the field to deliver water to crops, not a series of sprinklers.		
(D)	**Correct.** Spray irrigation uses large sprinkler systems that roll back and forth across a field to distribute water to crops. This method results in a high amount of evaporative loss.		

Question 12

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		EIN-2.F: Describe the benefits and drawbacks of different methods of irrigation.	Irrigation Methods
(A)	Incorrect. Drip irrigation uses a series of irrigation tubes to water plant roots directly.		
(B)	Incorrect. Flood irrigation does not use small water channels; it involves flooding a field with water.		
(C)	**Correct.** In furrow irrigation, a series of trenches or small channels are dug between crops in a field. Gravity allows water to seep into the soil, supplying water to roots and preventing waterlogging. The trenches, however, increase soil erosion in the crop field.		
(D)	Incorrect. Spray irrigation uses large sprinkler systems that roll back and forth across a field or rotate around a center pivot.		

Question 13

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		EIN-2.A: Explain the concept of the tragedy of the commons.	The Tragedy of the Commons
(A)	Incorrect. Depletion of crude oil is not an example of tragedy of the commons because when the crude oil is on private lands it is an owned resource.		
(B)	Incorrect. Requiring permits for grazing cattle on United States parklands ensures that the shared resource is not overused and degraded. Requiring permits for grazing is a sustainable practice if done correctly.		
(C)	Incorrect. Eutrophication is degrading the ecosystem; however, since the pond is owned by a farmer, it is not an example of the tragedy of the commons.		
(D)	**Correct.** The accumulation of plastics in the Great Pacific Garbage Patch, located in the North Pacific Ocean, is a tragedy of the commons since no one entity owns the ocean and many contribute to the problem that is degrading the ocean ecosystem.		

Question 14

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		STB-4.D: Identify the sources and potency of the greenhouse gases. STB-2.A: Identify the sources and effects of air pollutants.	Global Climate Change Introduction to Air Pollution
(A)	Incorrect. The primary anthropogenic sources for methane are the production and processing of natural gas and fermentation from livestock operations. There is not a significant amount of methane released from vehicles.		
(B)	**Correct.** The primary anthropogenic source for nitrous oxides is agriculture, including fertilizer use and manure decomposition.		
(C)	Incorrect. The primary anthropogenic source of chlorofluorocarbons is refrigerants, not fossil fuel combustion. Chlorofluorocarbons are synthetic materials that are produced for a variety of industrial uses.		
(D)	Incorrect. The primary anthropogenic source for carbon dioxide is fossil fuel combustion for electricity and transportation, not waste produced from homes.		

Question 15

Skill		Learning Objective	Topic
7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.		EIN-2.G: Describe the benefits and drawbacks of different methods of pest control.	Pest Control Methods
(A)	**Correct.** Using genetically engineered plants can lead to loss of genetic diversity of a crop when the advantageous genes that were introduced into the species are favored via natural selection.		
(B)	Incorrect. The genetically engineered plants are developed to require the use of less pesticides than plants that are not genetically engineered. This is an advantage, not a disadvantage, of genetically modified crops.		
(C)	Incorrect. The genetically engineered plants should not require more land to grow on than plants that are not genetically engineered.		
(D)	Incorrect. The genetically engineered plants are often resistant to disease (and have inserted genes that make them less likely to be affected by pests and fungi). This is an advantage, not a disadvantage, of genetically modifying crops.		

Question 16

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		STB-3.B: Describe the impacts of human activities on aquatic ecosystems.	Human Impacts on Ecosystems
(A)	Incorrect. A high level of dissolved oxygen and low biological oxygen demand at this location indicate a healthy stream.		
(B)	**Correct.** As nutrients such as nitrogen, phosphorus, or even raw sewage are introduced into the stream, the biological oxygen demand will increase and the dissolved oxygen will decrease as microorganisms decompose material and respire. At point B there is a rapid change in BOD and a decrease of dissolved oxygen, indicating the presence of a point-source pollutant.		
(C)	Incorrect. An elevated BOD and decreased dissolved oxygen at this location indicate the presence of more nutrients than is typical; however, the levels are not as high as they are farther upstream, where the discharge likely occurred.		
(D)	Incorrect. At location D the BOD has returned to low levels and the dissolved oxygen has increased, indicating little nutrient pollution remaining in the stream.		

Question 17

Skill		Learning Objective	Topic
3.A: Identify the author's claim.		ENG-3.K: Describe the effects of the use of solar energy in power generation on the environment.	Solar Energy
(A)	Incorrect. The author states that New York City has thousands of acres of available rooftop and that there are new incentives in place to install panels there.		
(B)	**Correct.** The author states that recent projects to install solar panels on New York City rooftops have been driven by the local and state governments in the form of tax breaks and other incentives.		
(C)	Incorrect. The author states that even though the panels produce only enough electricity to power a portion of the energy needs of the complex, the installation helps to fill the energy demand during peak times of the year.		
(D)	Incorrect. The author does not state that apartment residents are criticizing the installation or utilization of rooftop solar panels, nor that these projects are being reconsidered.		

Question 18

Skill		Learning Objective	Topic
3.B: Describe the author's perspective and assumptions.		ENG-3.K: Describe the effects of the use of solar energy in power generation on the environment.	Solar Energy
(A)	Incorrect. The author does not discuss the costs associated with the installation and maintenance of solar panels, but rather explains that tax breaks and incentives have driven the investment in solar energy generation.		
(B)	Incorrect. Although the author does state that New York City is currently ranked sixth in American cities for solar capacity, the author does not suggest that this ranking should affect future solar projects or that installation costs should be reduced.		
(C)	**Correct.** Throughout the article the author discusses that New York City is making progress in increasing its solar capacity, but it still is behind other major cities, such as Los Angeles, and should continue solar energy projects to meet the goal of 3 gigawatts of solar capacity by 2023.		
(D)	Incorrect. Although the author does state that New York City has some of the most expensive electricity in America, the author does not discuss that other energy alternatives should be considered for the city.		

Question 19

Skill		Learning Objective	Topic
3.C: Describe the author's reasoning (use of evidence to support a claim).		ENG-3.K: Describe the effects of the use of solar energy in power generation on the environment.	Solar Energy
(A)	Incorrect. The author states that the StuyTown project added about 3.9 megawatts to the solar capacity of the borough and does not discuss how it affected the solar capacity at the city level.		
(B)	**Correct.** The author states that the 9,000 new solar panels added about 3.9 megawatts to the solar capacity of the borough, enough to power 1,100 apartments.		
(C)	Incorrect. The author states that Los Angeles has the highest solar capacity of all other American cities and that its capacity is more than double that of New York City.		
(D)	Incorrect. The author states that by 2030, New York State is aiming for 70% of its power to be generated from renewable sources and not that the StuyTown project alone achieved this goal.		

Question 20

Skill		Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.		ENG-3.J: Describe the use of solar energy in power generation.	Solar Energy
(A)	Incorrect. Passive solar energy systems are not capable of storing energy captured from the Sun, so during winter months in the northeast, most solar panels would be underutilized.		
(B)	Incorrect. Although active solar energy systems will store energy captured from the Sun, placing the panels in shaded areas and facing them northeast will not maximize sun exposure and will reduce electricity generation.		
(C)	Incorrect. Passive solar energy systems are not capable of storing energy captured from the Sun, so during winter months in the northeast, most solar panels would be underutilized. Also, placing the panels in shaded areas and facing them northeast will not maximize sun exposure and will reduce electricity generation.		
(D)	**Correct.** Active solar energy systems will store energy captured from the Sun to be used when sun exposure is limited, and positioning the panels to face south on rooftops will maximize sun exposure.		

Question 21

Skill	Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.	EIN-1.A: Explain age structure diagrams.	Age Structure Diagrams

(A)	**Correct.** Countries experiencing rapid population growth have a large proportion of younger people but a small proportion of older adults. The rapid population growth in this country is attributed to the large proportion of individuals that are of pre-reproductive and reproductive age.
(B)	Incorrect. Countries with slow population growth can have a large proportion of younger people in the population, but they also have a high proportion of older adults in the population that are post-reproductive. There are relatively few older adults in this population, indicating that this country is most likely experiencing rapid population growth.
(C)	Incorrect. Countries with a declining population growth have a much higher proportion of the population as older adults than young adults of reproductive age. The population in this age structure diagram has a high proportion of the population under age 44, which indicates that the population is experiencing rapid growth.
(D)	Incorrect. Countries with no net change in population growth tend to have relatively equal proportions of older and younger adults in the population. The population in this age structure diagram has a high proportion of the population under age 44, which indicates that the population is experiencing rapid growth.

Question 22

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ERT-2.A: Explain levels of biodiversity and their importance to ecosystems.	Introduction to Biodiversity
(A)	Incorrect. Although population sizes of multiple species contribute to biodiversity measurements as a function of evenness, the population size of a single species does not.		
(B)	Incorrect. Overall population density is not a measurement for species biodiversity, as it does not provide information about the total number of different species in an area.		
(C)	**Correct.** The number of different species is a primary measure of biodiversity that is also known as species richness.		
(D)	Incorrect. The depth in the soil at which organisms are found is a measure of their distribution, not ecosystem diversity.		

Question 23

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ERT-4.D: Describe the structure and composition of the Earth's atmosphere.	Earth's Atmosphere
(A)	Incorrect. Carbon dioxide (CO_2) comprises less than 1% of Earth's atmosphere.		
(B)	**Correct.** Nitrogen (N_2) comprises about 78% of Earth's atmosphere.		
(C)	Incorrect. Methane (CH_4) comprises less than 1% of Earth's atmosphere.		
(D)	Incorrect. Oxygen (O_2) comprises roughly 21% of Earth's atmosphere.		

Question 24

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		STB-2.D: Describe natural sources of CO2 and particulates.	Atmospheric CO2 and Particulates
(A)	Incorrect. Plants take in carbon dioxide during photosynthesis and release oxygen, therefore removing CO_2 from the atmosphere rather than adding CO_2 .		
(B)	**Correct.** Volcanoes release many gases during eruptions, including carbon dioxide.		
(C)	Incorrect. Deposition of sediments (such as in carbonate formation) would trap CO_2 in rock, not release it to the atmosphere.		
(D)	Incorrect. Burial of organic matter traps carbon dioxide underground and sequesters it from the atmosphere. Combustion of this organic matter (such as during fossil fuel combustion) can release this stored carbon.		

Question 25

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts. 7.A: Describe environmental problems.		STB-3.D: Describe the effects of endocrine disruptors on ecosystems. STB-3.C: Describe endocrine disruptors.	Endocrine Disruptors
(A)	**Correct.** Endocrine disruptors alter hormone levels, which are linked to gender imbalances in amphibian species.		
(B)	Incorrect. Carcinogens are compounds that cause cancer, not gender imbalances.		
(C)	Incorrect. Nitrogen fertilizers are linked to eutrophication in ponds, not to gender imbalances.		
(D)	Incorrect. Heavy metals are toxic and can lead to death, but they are not linked to gender imbalances.		

Question 26

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually.		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem.	Human Impacts on Biodiversity
(A)	Incorrect. Scenario 1 experienced habitat loss as a result of shrinking patch size (less available habitat). Scenario 3 also experienced habitat fragmentation.		
(B)	Incorrect. Both Scenarios 1 and 2 experienced habitat loss, but Scenario 3 experienced both habitat loss and fragmentation.		
(C)	**Correct.** All scenarios experienced habitat loss as a result of decreasing patch size (Scenarios 1 and 3) and eliminated patches (Scenario 2), but only Scenario 3 experienced habitat fragmentation.		
(D)	Incorrect. All scenarios experienced habitat loss, not fragmentation, and only Scenario 3 experienced habitat fragmentation.		

Question 27

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem. ERT-2.A: Explain levels of biodiversity and their importance to ecosystems.	Human Impacts on Biodiversity Introduction to Biodiversity
(A)	Incorrect. Territory size is determined by several factors including food availability, body size, and mating behaviors. It would not be likely that decreased habitat area would lead to an increase in territory size for large mammals.		
(B)	Incorrect. Native species living in isolated or smaller habitat patches are likely to experience a decrease, not an increase, in genetic diversity.		
(C)	**Correct.** A loss of habitat leads to a loss of specialist species (and then generalist species). Each potential scenario would experience habitat loss from the original habitat area, so it would be expected that the number of specialist species would decrease.		
(D)	Incorrect. Habitat loss and/or fragmentation is likely to lead to an increase, not a decrease, in invasive species. Habitat loss decreases the stability of an ecosystem and habitat fragmentation increases the edge-to-interior ratio or edge effect, leading to the ecosystem being more susceptible to the threat of invasive species.		

Question 28

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem.	Human Impacts on Biodiversity
(A)	Incorrect. Replanting native habitat would increase, not decrease, habitat size and lead to more niches. The diagram does not show that native species were replanted.		
(B)	**Correct.** The construction of structures such as roads, railroads, pipelines, and electric lines are a common cause of the habitat fragmentation observed in Scenario 3.		
(C)	Incorrect. An increased edge-to-interior ratio is a result of the habitat fragmentation observed in Scenario 3, not a cause of it.		
(D)	Incorrect. Building habitat corridors would result in narrow links between habitat patches, not in habitat loss and further patch division. The diagram does not show any connections between patches.		

Question 29

Skill	Learning Objective	Topic
2.C: Explain how environmental concepts and processes represented visually relate to broader environmental issues.	EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem. STB-4.E: Identify the threats to human health and the environment posed by an increase in greenhouse gases. STB-4.F: Explain how changes in climate, both short- and long-term, impact ecosystems.	Human Impacts on Biodiversity Increases in The Greenhouse Gases Global Climate Change

(A)	**Correct.** Increased sea level as a result of climate change could decrease the land areas as shown in Scenario 1. Rising sea level would encroach on coastal areas, decreasing the available habitat in the pattern shown in the diagram.
(B)	Incorrect. Although increased carbon dioxide concentrations could cause an increase in plant growth, Scenario 1 shows a decrease in habitat size, not an increase.
(C)	Incorrect. Climate change is causing increased, not decreased, temperatures. Additionally, there is no evidence in the diagram to suggest that unsuitable abiotic conditions could cause the loss of land area or habitat loss as shown in Scenario 1.
(D)	Incorrect. Although decreased precipitation could be a result of climate change, it would not reduce land area as shown in Scenario 1.

Question 30

Skill		Learning Objective	Topic
5.B: Describe relationships among variables in data represented.		ERT-2.F: Describe ecological tolerance.	Ecological Tolerance
(A)	Incorrect. Based on the data in the table, the frog embryos did not survive when exposed to a pH of 6.5. Additionally, there is not enough data in the table to support this claim, since there is no data provided for hatching above a pH of 6.5.		
(B)	**Correct.** Based on the data in the table, the frog embryos can only tolerate environmental conditions that have a pH in the range of 4.5 to 6. Frog embryos in the study did not hatch at a pH of 6.5 or a pH of 4 or less, indicating the range for survival is between a pH of 4.5 and 6.		
(C)	Incorrect. Based on the data in the table, although the frog embryos survived in environmental conditions with a pH range of 4.5 to 5, the frog embryos did not survive when exposed to a pH of 4 or less. There is no data provided for hatching below a pH of 3.5.		
(D)	Incorrect. Based on the data in the table, the frog embryos in the study did not survive when exposed to a pH of 4 or less. There is no data provided for hatching below a pH of 3.5.		

Question 31

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		STB-3.E: Describe the impacts of human activity on wetlands and mangroves. ERT-2.B: Describe ecosystem services.	Human Impacts on Wetlands and Mangroves Ecosystem Services
(A)	Incorrect. Aesthetic inspiration is considered a cultural service of wetlands, not a supporting service.		
(B)	Incorrect. Ecotourism provides an economic benefit, not an ecological service.		
(C)	Incorrect. The plants of some wetlands may act as a carbon sink but not as a major reservoir for nitrogen. Additionally, carbon sequestration and storage is considered a regulating service and not a supporting service.		
(D)	**Correct.** Wetlands are a source of habitats, food, and shelter for many fish and wildlife.		

Question 32

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		ERT-4.D: Describe the structure and composition of the Earth's atmosphere.	Earth's Atmosphere
(A)	**Correct.** As the lowest atmospheric layer, the troposphere is most influenced by reradiated heat from Earth's surface, which makes the base of the troposphere warmer than the top layer. This leads to convection, turbulence, and clouds, which cause most weather phenomena.		
(B)	Incorrect. The stratosphere is less affected by reradiated heat because it is farther from Earth's surface. Although some weather may extend into the lower portion of the stratosphere, most weather occurs in the troposphere.		
(C)	Incorrect. The mesosphere is too far from Earth's surface for rising heat to significantly affect it; therefore, no weather occurs in this layer.		
(D)	Incorrect. Although the thermosphere blocks harmful ultraviolet radiation from the Sun, weather does not occur in this layer.		

Question 33

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		ENG-3.J: Describe the use of solar energy in power generation.	Solar Energy
(A)	Incorrect. Passive solar heating design does not generate electricity. Solar-power photovoltaic panels convert the Sun's rays into electricity, but not passive solar heating.		
(B)	Incorrect. Passive solar heating design does not include electrically powered devices. Active solar heaters use solar energy to heat a fluid, but not passive solar heating.		
(C)	Incorrect. Passive solar heating design uses solar energy. Warm water pumped from underground is related to geothermal energy.		
(D)	**Correct.** Passive solar heating design relies on stone or other materials in the walls and floors that are warmed by the sun and radiate heat into the building.		

Question 34

Skill		Learning Objective	Topic
5.A: Describe patterns or trends in data.		ERT-1.A: Explain how the availability of resources influences species interactions. ERT-3.F: Explain how resource availability affects population growth.	Introduction to Ecosystems Population Growth and Resource Availability
(A)	Incorrect. This value is the wolf population size in 1995, when they were first introduced and is not their maximum population size.		
(B)	Incorrect. This value could have been concluded by looking at the elk data in between 1996 and 1999 but reading the right y-axis (for wolf population size).		
(C)	**Correct.** Based on the data, the peak wolf population occurred between 2002 and 2005 and was between 170 and 175 wolves.		
(D)	Incorrect. This value could have been concluded by looking at the peak elk population data but reading the right y-axis (for wolf population size).		

Question 35

Skill		Learning Objective	Topic
5.B: Describe relationships among variables in data represented.		ERT-1.A: Explain how the availability of resources influences species interactions.	Introduction to Ecosystems
(A)	Incorrect. In 1995 there were about 12,000 elk per square kilometer and 4,000 at the end of the data collection. The population size of the elk did not steadily increase after the introduction of wolves.		
(B)	**Correct.** After the introduction of wolves into Yellowstone, the overall population size of the northern range elk began decreasing. In 1995 there were about 12,000 elk in the northern range population and 4,000 at the end of the data collection.		
(C)	Incorrect. In 1995 there were about 12,000 elk per square kilometer and 4,000 at the end of the data collection. The population size of the elk did not remain stable after the introduction of wolves.		
(D)	Incorrect. In 1995 there were about 12,000 elk per square kilometer and 4,000 at the end of the data collection. The overall trend is a decrease, and the data do not support an overshoot.		

Question 36

Skill		Learning Objective	Topic
7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.		ERT-1.A: Explain how the availability of resources influences species interactions.	Introduction to Ecosystems
(A)	Incorrect. Although this statement is true and the wolves are causing a trophic cascade, the effects of this event are an advantage to the wolves' reintroduction to Yellowstone, not a disadvantage.		
(B)	**Correct.** There are no controls preventing wolves from leaving the park and they could prey on livestock they come into contact with outside of the park boundaries.		
(C)	Incorrect. As large mammals and top predators, wolves are K-selected and breed relatively slowly. There is little chance they will spread far beyond Yellowstone from this introduction. Additionally, the wolves are native to the area, but they were driven out by humans so they are not an invasive species.		
(D)	Incorrect. This is a reintroduction to the park. Wolves were part of the ecosystem before they were wiped out through hunting.		

Question 37

Skill		Learning Objective	Topic
6.C: Calculate an accurate numeric answer with appropriate units.		EIN-2.M: Describe the effects of urbanization on the environment.	Impacts of Urbanization
(A)	Incorrect. This value is from determining the change in runoff from urban areas to forested areas. There is a greater amount of water that runs off in urban areas (55% compared to 10%), so the change in the amount of runoff is a positive number because the amount of runoff increases.		
(B)	Incorrect. This value is from determining the change in surface infiltration from forested areas to urban areas; incorrect data were used for this calculation based on the prompt.		
(C)	Incorrect. This value is from determining the change in surface infiltration from urban areas to forested areas; incorrect data were used for this calculation based on the prompt.		
(D)	**Correct.** This value compares the amount of runoff in forested areas (10%) to the amount in urban areas (55%) using the equation for percent change ($\frac{0.55 - 0.10}{0.10} \times 100 = 450\%$).		

Question 38

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		STB-1.B: Describe methods for mitigating problems related to urban runoff.	Methods to Reduce Urban Runoff
(A)	Incorrect. Decreasing the number of trees in urban areas would increase the amount of runoff. Tree roots take up water and create soil conditions that promote infiltration.		
(B)	Incorrect. Increasing the number of trees will increase the amount of transpiration because more water will evaporate from leaf stomata as the plants carry out photosynthesis. Also, this option does not address the concern of decreasing urban runoff.		
(C)	**Correct.** A more porous pavement would allow water to be absorbed by the natural ground cover below, therefore decreasing runoff and increasing the volume of water that infiltrates the soil.		
(D)	Incorrect. Traditional pavement leads to urban runoff by decreasing the amount of water that infiltrates the soil. More porous pavement should be used to decrease urban runoff.		

Question 39

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually.		ERT-1.G: Explain the steps and reservoir interactions in the hydrologic cycle.	The Hydrologic (Water) Cycle
(A)	**Correct.** The evaporation rate is the amount of water that is returned to the atmosphere over a given period of time. As water evaporates, it cools and condenses as clouds and is returned to the earth as precipitation.		
(B)	Incorrect. The runoff rate is the amount of water that does not infiltrate the soil over a given period of time and is not the cause of precipitation.		
(C)	Incorrect. The surface infiltration rate is the amount of water that infiltrates the surface layers of the soil over a given period of time and is not the cause of precipitation.		
(D)	Incorrect. The deep infiltration rate is the amount of water that infiltrates the deeper layers of the soil over a given period of time and is not the cause of precipitation.		

Question 40

Skill	Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.	ERT-3.B: Identify differences between K- and r-selected species. EIN-4.A: Explain the environmental problems associated with invasive species and strategies to control them.	K-Selected r-Selected Species Invasive Species

(A)	Incorrect. Although the spotted lanternfly is native to Asia and is an invasive species in the United States, the species is not **K**-selected. **K**-selected species are characterized by long life spans and few offspring. The short life span and the large number of offspring indicate that the spotted lanternfly is an **r**-selected species.
(B)	Incorrect. The spotted lanternfly is neither a **K**-selected nor an endangered species in the United States; it is native to Asia. **K**-selected species are characterized by long life spans and few offspring. The short life span and the large number of offspring indicate that the spotted lanternfly is an **r**-selected species. The generalist diet and the expanding range of the spotted lanternfly are characteristics of invasive species.
(C)	**Correct.** The spotted lanternfly produces many offspring and matures quickly, which are characteristics of an **r**-selected species. The spotted lanternfly is native to Asia and is an invasive species in the United States, with human activity increasing the range of the species.
(D)	Incorrect. Although the spotted lanternfly is an **r**-selected species, it is native to Asia and is an invasive species in the United States, not an endangered species. The spotted lanternfly produces many offspring and matures quickly, which are characteristics of an **r**-selected species. Its generalist diet and the expanding range of the spotted lanternfly outside of its native Asia are characteristics of invasive species. The large numbers of the spotted lanternfly in the Northeastern United States are a major threat to crops and trees.

Question 41

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		ENG-3.B: Describe trends in energy consumption. ENG-3.C: Identify types of fuels and their uses.	Global Energy Consumption Fuel Types and Uses
(A)	Incorrect. Bituminous coal is primarily used for generating electricity and not for heating and cooking purposes. Bituminous coal also has a low moisture content, not a high moisture content, compared with other types of coal.		
(B)	Incorrect. A cogeneration system generates heat and electricity, but it is not designed for individual homes nor is it a technology readily found in developing countries. A disadvantage of cogeneration is that the development of the system can be expensive, and it is only suitable when both hot water and electricity are needed at high and consistent levels.		
(C)	**Correct.** Biomass such as wood, peat, dung, and other types of organic waste is cheap and easily accessible in developing countries. It is the most viable option in developing countries where technology is not universally available.		
(D)	Incorrect. Natural gas infrastructure is not prevalent in developing countries because of the infrastructure cost and the need to import the resource.		

Question 42

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		STB-4.F: Explain how changes in climate, both short- and long-term, impact ecosystems.	Global Climate Change
(A)	Incorrect. Increased permafrost melting has led to an increase in methane gas released, not absorbed. Additionally, methane gas in the atmosphere leads to an increase, not a decrease, in greenhouse warming.		
(B)	**Correct.** Warming temperatures lead to a decrease in the amount of sea ice. This increases the amount of land surface and ocean that is dark in color, which leads to a decreased albedo in the Arctic. The decreased albedo leads to less solar energy reflected and more solar energy absorbed. This increased absorption leads to warming temperatures and a decrease in sea ice that continues a cycle. This is an example of a positive feedback loop that occurs in the Arctic.		
(C)	Incorrect. Although the increase in cloud cover does lead to a decrease in the amount of energy reaching the surface of Earth, this is an example of a negative, not positive, feedback loop.		
(D)	Incorrect. Although increased precipitation does lead to an increase in high albedo coverage in polar regions, this is not an example of a feedback loop. The number of polar bears and the increased habitat do not directly influence the amount of precipitation that occurs.		

Question 43

Skill		Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.		ERT-4.B: Describe the characteristics and formation of soil.	Soil Formation and Erosion
(A)	Incorrect. Slash-and-burn agriculture involves rapid removal of native forest to plant crops. The rapid removal of native species leads to increased soil erosion.		
(B)	Incorrect. The main goal of integrated pest management is to prevent the spread of pests and allow for less use of pesticides. It does not focus on methods to reduce erosion.		
(C)	Incorrect. Single-crop farming quickly depletes soil of nutrients and moisture, which can exacerbate levels of soil erosion.		
(D)	**Correct.** Terrace farming involves leveling portions of steep slopes. This leveling decreases the speed and the amount of runoff, which slows the rate of soil erosion.		

Question 44

Skill		Learning Objective	Topic
6.C: Calculate an accurate numeric answer with appropriate units.		EIN-1.C: Explain how human populations experience growth and decline.	Human Population Dynamics
(A)	**Correct.** Using the data in the table, the growth rate is determined by subtracting death rate from the birth rate and multiplying by 100 $(\frac{11.9-8.1}{1{,}000}\times 100)$.		
(B)	Incorrect. This is the growth rate in 2014, not 2019.		
(C)	Incorrect. This value was obtained by dividing the death rate by the birth rate. Growth rate is determined by subtracting the death rate from the birth rate and multiplying by 100.		
(D)	Incorrect. This value was obtained by dividing the death rate by the birth rate for the 2014 values. Growth rate is determined by subtracting the death rate from the birth rate and multiplying by 100.		

Question 45

Skill		Learning Objective	Topic
6.A: Determine an approach or method aligned with the problem to be solved. 6.C: Calculate an accurate numeric answer with appropriate units.		EIN-1.C: Explain how human populations experience growth and decline.	Human Population Dynamics
(A)	Incorrect. This answer correctly uses the rule of 70 but divides 70 by 49 instead of 0.49.		
(B)	Incorrect. This answer multiplies the growth rate (0.49) by 70 instead of dividing. Doubling time is 70 divided by the given growth rate.		
(C)	**Correct.** Doubling time is calculated using the rule of 70. The rule of 70 states that doubling time is 70 divided by the growth rate, $(\frac{70}{0.49} = 142.9 \text{ years})$.		
(D)	Incorrect. This answer makes two mistakes. It multiplies instead of divides 49% (not 0.49%) by 70.		

Question 46

Skill		Learning Objective	Topic
6.A: Determine an approach or method aligned with the problem to be solved.		EIN-1.C: Explain how human populations experience growth and decline.	Human Population Dynamics
(A)	Incorrect. This calculation uses the incorrect formula for percent change by only subtracting the values and multiplying by 100. This method does not divide the difference between the data points by the initial data point.		
(B)	**Correct.** The formula to calculate percent change is taking the difference between the final data point and initial data point, dividing that value by the initial data point, and then multiplying the final value by 100:$(\frac{11.9 - 17.6}{17.6} \times 100)$.		
(C)	Incorrect. This calculation uses an incorrect formula for percent change and adds the data for 1994 and 2019 instead of subtracting the data.		
(D)	Incorrect. This calculation uses the incorrect formula for percent change and only divides the data, without finding the difference between the final data point and initial data point.		

Question 47

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		ENG-2.A: Explain how the Sun's energy affects the Earth's surface.	Solar Radiation and Earth's Seasons
(A)	Incorrect. The number of days in a year is determined by Earth's revolutionary path around the Sun; it would not be changed by a change in axial tilt.		
(B)	Incorrect. Volcanic activity is determined by heat flow inside Earth, not the tilt of Earth's axis.		
(C)	Incorrect. Changing the angle of the axis would alter where perpendicular solar rays strike Earth, changing the distribution of energy but not the total amount of energy.		
(D)	**Correct.** Axial tilt determines where the Sun's rays strike Earth. At a steeper tilt, the angle of the Sun's rays, and therefore the amount of energy, would vary more over the course of a year and lead to seasonal changes experienced over the course of a year. Less tilt means less seasonality.		

Question 48

Skill		Learning Objective	Topic
7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.		EIN-2.I: Describe the benefits and drawbacks of different methods of meat production.	Meat Production Methods
(A)	Incorrect. While this is a true statement, it does not describe a benefit of concentrated animal feedlots. In fact, this may allow for easier contamination of groundwater and surface water nearby, which is an unintended consequence of the operations.		
(B)	Incorrect. Animals in CAFOs are usually fed grains to help them grow faster and are rarely, if ever, grass-fed.		
(C)	**Correct.** Concentrating the raising of many animals in one location allows for more efficiency in feeding the animals and processing the meat. This generally leads to lower costs in meat production than the costs of production from organic or free-range operations.		
(D)	Incorrect. The large amounts of animal waste can easily enter local waterways. Farms with less concentrated animal feeding produce far less waste that disperses into the fields naturally, and more nutrients can be filtered by riparian zones, wetlands, and other natural areas. Local waterways are usually more contaminated near CAFOs than those near organic or free-range operations.		

Question 49

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes. 7.A: Describe environmental problems.		STB-2.B: Explain the causes and effects of photochemical smog and methods to reduce it.	Photochemical Smog
(A)	Incorrect. Without the presence of UV light from the Sun, VOCs and NO_x will not react with each other to produce photochemical smog.		
(B)	Incorrect. Nitrogen oxides (NO_x) must be present in addition to UV light from the Sun in order to react with VOCs to produce photochemical smog.		
(C)	**Correct.** Photochemical smog is created when VOCs and nitrogen oxides (NO_x) react with ultraviolet (UV) light from the Sun.		
(D)	Incorrect. CO_2 is not a component of photochemical smog, and nitrogen oxides (NO_x) are missing from this option.		

Question 50

Skill		Learning Objective	Topic
2.A: Describe characteristics of an environmental concept, process, or model represented visually.		ERT-2.I: Describe ecological succession.	Ecological Succession
(A)	Incorrect. Although the exposed rocks at the beginning of the diagram support the claim this is primary succession, the result of a climax community with mostly shade-tolerant species (as the canopy prevents direct sunlight from reaching many of the species) is possible with both primary and secondary succession.		
(B)	**Correct.** Primary succession starts without any soil. Stage I of the diagram shows bare rock, an indication that primary succession is taking place.		
(C)	Incorrect. The image depicts primary succession because it starts with exposed rock (no soil) while secondary succession starts with soil. However, it is true that secondary succession starts with intermediate species like grasses and weeds.		
(D)	Incorrect. The image depicts primary succession because it starts with exposed rock (no soil) while secondary succession starts with soil. Additionally, the result of a climax community with mostly shade-tolerant species (as the canopy prevents direct sunlight from reaching many of the species) is possible with both primary and secondary succession.		

Question 51

Skill		Learning Objective	Topic
2.B: Explain relationships between different characteristics of environmental concepts, processes, or models represented visually. a. In theoretical contexts. b. In applied contexts.		ERT-2.I: Describe ecological succession. ERT-2.J: Describe the effect of ecological succession on ecosystems.	Ecological Succession
(A)	Incorrect. At this stage there is only bare rock; there are no organisms or soil present.		
(B)	**Correct.** At this stage, organisms like lichen, fungi, and moss can grow on rocks without soil and are among the first life-forms. Pioneer species are the first species to colonize an area in succession.		
(C)	Incorrect. At this stage, grasses begin to grow in nutrient-rich topsoil created by the breakdown of rocks and decomposition of lichen and moss.		
(D)	Incorrect. At this stage, increased soil depth and organic matter result in an increased variety of plant species that mix with grasses.		

Question 52

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		ERT-2.I: Describe ecological succession.	Ecological Succession
(A)	Incorrect. Soil seed banks are natural storage of seeds in leaf litter or in the soil of many ecosystems. Mosses reproduce using spores and do not have seeds or flowers. A seed bank could not exist in the soil until later stages of succession.		
(B)	**Correct.** Mosses colonize the thin soil created by lichen and further break down rock, creating the soil needed to support grasses.		
(C)	Incorrect. Trees, not mosses, that emerge in stages V , VI , and VII provide shade and reduce surface temperatures.		
(D)	Incorrect. The formation of habitats that can support bird and mammal species requires a greater diversity of plants that are found in later stages of succession.		

Question 53

Skill		Learning Objective	Topic
3.A: Identify the author's claim.		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem.	Human Impacts on Biodiversity
(A)	**Correct.** This claim is supported by statements from the passage. The author argues that habitat range reduction is the primary indicator of population decline.		
(B)	Incorrect. While this is a true statement, the author does not discuss the poleward shift of species as a result of climate change. This is not the author's main claim in the article.		
(C)	Incorrect. The author does not discuss the impact of excess carbon dioxide on plant populations in the article.		
(D)	Incorrect. The author states that mammal populations are more heavily affected than other species and so their populations are decreasing.		

Question 54

Skill		Learning Objective	Topic
3.B: Describe the author's perspective and assumptions.		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem.	Human Impacts on Biodiversity
(A)	Incorrect. Mass extinctions have occurred throughout Earth's history. The current loss of biodiversity is considered to be Earth's sixth mass extinction, not its first. Additionally, the article does not support this perspective.		
(B)	**Correct.** The passage indicates that the majority of scientific research has focused primarily on species that have gone completely extinct. The author notes that previous estimates of global extinction rates have been too low, partly based on the focus on species that are completely extinct.		
(C)	Incorrect. The passage does not state whether habitat destruction was previously limited to areas of low biodiversity or that it currently targets those areas.		
(D)	Incorrect. The passage indicates that scientists do not necessarily agree on a definition for "population", not for "extinction."		

Question 55

Skill		Learning Objective	Topic
3.C: Describe the author's reasoning (use of evidence to support a claim).		EIN-4.C: Explain how human activities affect biodiversity and strategies to combat the problem.	Human Impacts on Biodiversity
(A)	Incorrect. The passage states that species have rebounded after environmental pressures are removed.		
(B)	Incorrect. This is a true statement from the article, but it is not evidence that extinction rates will continue to increase.		
(C)	**Correct.** The passage states that as the negative effects of climate change continue to increase, extinction rates will also increase because climate change increases the negative effects of habitat destruction and pollution on populations.		
(D)	Incorrect. The passage states that pollution and deforestation result in range size decreases, not increases.		

Question 56

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		STB-2.I: Describe the effects of acid deposition on the environment.	Acid Rain
(A)	Incorrect. This describes an area that is likely to experience heavy acid rain; however, being downwind of a coal-burning electrical plant would not offer protection against the negative effects of acid rain.		
(B)	Incorrect. Fog is a sign of an inversion, which would prevent the moist air from leaving the valley. This would intensify the impact of acid in the moist air, introducing more acid into the environment with no increased buffering ability.		
(C)	**Correct.** Regions that have limestone bedrock can neutralize the effect of acid rain on lakes and streams. Limestone is naturally basic and neutralizes acid rain in the soil.		
(D)	Incorrect. Granite, unlike limestone, contains no neutralizing components and thus would have little to no impact on reducing the acidity of lakes and streams.		

Question 57

Skill		Learning Objective	Topic
1.A: Describe environmental concepts and processes.		EIN-1.C: Explain how human populations experience growth and decline.	Human Population Dynamics
(A)	Incorrect. Resources like food and water decrease as population density increases; therefore, resource scarcity is classified as a density-dependent control. A smaller population size has greater resource availability.		
(B)	Incorrect. The spread of infectious disease increases in denser populations; therefore, this is a density-dependent control.		
(C)	**Correct.** Climatic factors, including drought, floods, hurricanes, and wildfires, affect populations regardless of initial population density.		
(D)	Incorrect. Available habitat decreases as population density increases; therefore, available habitat is a density-dependent control. A smaller population has greater habitat availability.		

Question 58

Skill		Learning Objective	Topic
4.A: Identify a testable hypothesis or scientific question for an investigation.		STB-4.H: Explain the causes and effects of ocean acidification.	Ocean Acidification
(A)	**Correct.** Ocean acidification is caused by increased dissolved carbon dioxide concentrations. The carbon dioxide reacts with water to create carbonic acid, which dissociates to release H^+ ions, decreasing the water pH. Ocean acidification is likely to decrease the survivorship of the fish if it affects fish the way it affects shellfish.		
(B)	Incorrect. Increased concentrations of carbon dioxide in the atmosphere are associated with warmer atmospheric temperatures. An increased concentration of carbon dioxide in the ocean does not directly heat the water and is associated with a decrease in the pH of the water. A decrease in water temperature is not linked to carbon dioxide and therefore is not the most likely hypothesis for this study.		
(C)	Incorrect. The age of fish is not an appropriate variable here. All fish should start at the same age in this study. This hypothesis uses ages of fish as the independent variable, but it does not refer to the change in carbon dioxide levels or ocean acidification. This is not the most likely hypothesis for the study.		
(D)	Incorrect. Ocean acidification is shown to decrease calcification in invertebrates such as corals and it has led to a decrease in bone density in parts of fish skeletons. Ocean acidification decreases the availability of calcium carbonate.		

Question 59

Skill	Learning Objective	Topic
5.D: Interpret experimental data and results in relation to a given hypothesis.	EIN-4.A: Explain the environmental problems associated with invasive species and strategies to control them.	Invasive Species

(A)	Incorrect. Although the data in the graph support the researchers' hypothesis, it is not because there is a greater biodiversity at sites with cane toads. The sites with cane toads present had fewer species than sites where cane toads were absent, which supports the researchers' hypothesis that cane toads negatively affect native species.
(B)	**Correct.** The cane toads negatively affect the native species in Australian ecosystems, which is supported by the decreased biodiversity in the sites where cane toads are present. The average number of species in sites without cane toads is 18, and the average number of species in sites with cane toads is 12.5.
(C)	Incorrect. Although there is less biodiversity at sites with cane toads, these data do support the researchers' hypothesis that cane toads negatively affect native species. The results in the graph do support the original hypothesis given.
(D)	Incorrect. There is a greater diversity of species at the sites where cane toads are absent. These data support the researchers' hypothesis that cane toads negatively affect native species. The results in the graph do support the original hypothesis given.

Question 60

Skill	Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.	EIN-3.A: Define lethal dose 50% (LD50).	Lethal Dose 50% (LD50)

(A)	Incorrect. LD50 is the dose of substance that is lethal to 50% of the population. Since aspirin has an LD50 value of 1,000 mg / kg and vinegar has an LD50 value of 3,300 mg / kg, it would take less aspirin to reach a lethal dose, making it more toxic than vinegar.
(B)	Incorrect. LD50 is the dose of substance that is lethal to 50% of the population. Since table salt has an LD50 value of 3,320 mg / kg and vinegar has an LD50 value of 3,300 mg / kg, it would take slightly less vinegar to reach a lethal dose, making it slightly more toxic than table salt.
(C)	**Correct.** LD50 is the dose of substance that is lethal to 50% of the population. Since antifreeze has the lowest LD50 value of all the substances in the table, it would take less antifreeze to reach a lethal dose than any of the other substances in the table, making it the most toxic.
(D)	Incorrect. LD50 is the dose of substance that is lethal to 50% of the population. Since table salt has the highest LD50 value as compared to the other substances in the table, it would take more table salt to reach a lethal dose than any of the other substances, making it the least toxic substance.

Question 61

Skill	Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts. 7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.	EIN-4.A: Explain the environmental problems associated with invasive species and strategies to control them.	Invasive Species

(A)	Incorrect. Silver carp were intentionally introduced in an effort to control large algal blooms in aquaculture facilities, farm ponds, municipal wastewater treatment facilities, and sewage lagoons. This was the intended and positive result of introducing silver carp into the United States.
(B)	Incorrect. An introduced species, such as silver carp, is often able to outcompete native species for food and habitat because it lacks natural predators. Additionally, silver carp feed on plankton and algae, which are readily available as prey. Silver carp are thriving in the United States.
(C)	Incorrect. Silver carp did not become a keystone species in the United States and increase biodiversity; rather, they are an invasive species that overpopulated and caused native populations to struggle for resources. Many native fish species are in decline because of pressure from the thriving carp populations. Based on the stimulus, silver carp are best described as an invasive species.
(D)	**Correct.** Silver carp have rapidly growing populations that have disrupted native aquatic ecosystems because they are not controlled by natural predators. The carp are large fish that quickly consume a variety of prey and outcompete native fish, causing a threat to many river and lake ecosystems.

Question 62

Skill		Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.		ERT-4.C: Describe similarities and differences between properties of different soil types.	Soil Composition and Properties
(A)	Incorrect. Manure and organic-matter amendments help increase the water-holding capacity of the soil, whereas inorganic spray fertilizers do not affect the permeability of the soil. This would not decrease soil saturation.		
(B)	Incorrect. Clay has very low permeability, so adding clay would not help facilitate the flow of water through the soil, and the soil would remain overly saturated.		
(C)	**Correct.** Sand has very high permeability. Adding sand to the soil with help facilitate water flow through the soil and decrease the saturation of the soil.		
(D)	Incorrect. Contour plowing would slow the rate of water runoff, which in this case would lead to further flooding and potential root rot.		

Question 63

Skill		Learning Objective	Topic
7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.		STB-2.H: Describe acid deposition.	Acid Rain
(A)	Incorrect. This describes a positive intended result, not a consequence, of measures to regulate fossil fuel additives, not acid rain.		
(B)	**Correct.** Crops (and plants) rely on sulfur as an essential nutrient to produce proteins. Without sulfur deposition from acid rain, farmers are increasingly using sulfur supplements to ensure crops have a consistent amount of sulfur available for growth.		
(C)	Incorrect. This describes a positive intended result, not a consequence, of measures implemented to control acid rain.		
(D)	Incorrect. Although a reduced need for nuclear fuel would lead to a reduction in uranium mining, nuclear power plants do not release SOx, so they are not a significant contributor to acid deposition.		

Question 64

Skill	Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts. 4.C: Describe an aspect of a research method, design, and/or measure used.	STB-3.B: Describe the impacts of human activities on aquatic ecosystems.	Human Impacts on Ecosystems

(A)	**Correct.** Macroinvertebrate sampling is often used in biological monitoring of streams. Macroinvertebrates reside in an ecosystem for several months to many years, and they are relatively immobile (compared to fish), which can be helpful in locating the sources of pollutants. Macroinvertebrates have varying responses to water chemistry, water quality, and physical habitat changes, making them good indicators of aquatic health.
(B)	Incorrect. Macroinvertebrates do not migrate, like fish, but remain in the same area over a period of time. Macroinvertebrates differ in their tolerance to pollution, making them reliable indicators for aquatic sampling.
(C)	Incorrect. Macroinvertebrates are bottom-dwelling insects that are mostly in the lower part of the food chain, so they would not be classified as top predators in an aquatic ecosystem. Additionally, measuring only the toxins that bioaccumulate or biomagnify does not give a complete picture of pollutants in the ecosystem.
(D)	Incorrect. The level of dissolved oxygen, number of nitrites, and temperature are discrete water-quality parameters that can be measured at given points, serving as physical and chemical tests. The use of biological macroinvertebrates is used to give insight in the area over a period of time, rather than just at a single time.

Question 65

Skill	Learning Objective	Topic
5.C: Explain patterns and trends in data to draw conclusions.	ENG-2.A: Explain how the Sun's energy affects the Earth's surface.	Solar Radiation and Earth's Seasons

(A)	Incorrect. If both locations were at the same latitude, the solar energy received at each location would be about the same throughout the year.
(B)	**Correct.** The highest solar radiation per unit area is received at the equator and decreases toward the poles. The consistently high rate of solar energy at Location 1 indicates that this location is close to the equator. The solar radiation received at a location on Earth's surface varies seasonally, with the most radiation received during the location's longest summer day. Location 2 is in the Northern Hemisphere because the greatest amount of solar energy occurs during the summer solstice in June.
(C)	Incorrect. The highest solar radiation per unit area is received at the equator and decreases toward the poles. The consistently high rate of solar energy at Location 1 indicates that this location is close to the equator and could be in the Northern or Southern Hemisphere. The solar radiation received at a location on Earth's surface varies seasonally, with the most radiation received during the location's longest summer day and the least on the shortest winter day. Location 2 is in the Northern Hemisphere because the greatest amount of solar energy occurs during the summer solstice in June. If Location 2 were in the Southern Hemisphere, there would be a very low amount of solar energy received in June.
(D)	Incorrect. A location close to the equator has a consistently high rate of solar energy. Location 1 has a relatively consistent rate of solar energy throughout the year, so it is close to the equator and could be in the Southern Hemisphere. However, Location 2 has a greater amount of solar energy received in June and July, which indicates that Location 2 is in the Northern Hemisphere, well away from the equator.

Question 66

Skill		Learning Objective	Topic
5.C: Explain patterns and trends in data to draw conclusions.		ENG-1.A: Explain how solar energy is acquired and transferred by living organisms.	Primary Productivity
(A)	Incorrect. The amount of solar energy received at Location 1 is relatively consistent, while the amount of solar energy received at Location 2 differs throughout the year, so the amount of gross primary productivity at each location is expected to be different.		
(B)	Incorrect. Location 2 receives much less solar energy in December compared to Location 1, so the amount of gross primary productivity in Location 2 is expected to be less than the gross primary productivity in Location 1.		
(C)	**Correct.** Primary productivity is the rate at which solar energy is converted into organic compounds via photosynthesis over a unit of time. Gross primary productivity is the total rate of photosynthesis in a given area. In March, there is more solar energy available to photosynthesizers in Location 1 than to photosynthesizers in Location 2, so gross primary productivity would be expected to be higher in Location 1.		
(D)	Incorrect. Location 2 receives less solar energy in September compared to Location 1, so the amount of gross primary productivity in Location 2 is expected to be less than the gross primary productivity in Location 1.		

Question 67

Skill		Learning Objective	Topic
5.C: Explain patterns and trends in data to draw conclusions.		ERT-1.B: Describe the global distribution and principal environmental aspects of terrestrial biomes.	Terrestrial Biomes
(A)	Incorrect. Taiga biomes are located in the Northern Hemisphere where there are seasonal differences in solar radiation.		
(B)	Incorrect. Tundra biomes are located in the Northern and Southern Hemispheres where there are seasonal differences in solar radiation.		
(C)	**Correct.** Tropical rain forests are characterized by consistently high solar radiation and temperature all year long.		
(D)	Incorrect. Temperate grasslands are found in both the Northern and Southern Hemispheres where there are seasonal differences in solar radiation.		

Question 68

Skill	Learning Objective	Topic
6.A: Determine an approach or method aligned with the problem to be solved.	EIN-2.J: Describe causes of and problems related to overfishing.	Impacts of Overfishing

(A)	Incorrect. Although the initial set up is correct, the equation is missing multiplying by 100. This choice does not convert the answer to a percent form.
(B)	Incorrect. Bycatch refers to nontarget species that are discarded, not those that are retained. This choice calculates the amount of retained fish, not bycatch, as a percent of the total. This choice also does not convert the answer to percent form because it does not multiply by 100.
(C)	Incorrect. This choice calculates the bycatch as a percent of the retained fish weight and not the total catch weight.
(D)	**Correct.** This choice correctly calculates the percent of bycatch. The total amount of fish caught is calculated by adding together the bycatch and the total brought to port ($6 \times 10^9 + 6.017 \times 10^8$). The bycatch volume ($6.017 \times 10^8$) is divided by the total catch and multiplied by 100 to get a percent.

Question 69

Skill	Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.	STB-1.C: Describe integrated pest management.	Integrated Pest Management

(A)	Incorrect. Using natural predators or parasites is a biological control, not a mechanical one.
(B)	**Correct.** Screens and traps are mechanical methods to lower pest populations. Mechanical methods use physical means such as fences or other barriers to manage pests.
(C)	Incorrect. Planting monocultures is not an integrated pest management approach, as a monoculture tends to attract more insect pests than a field with a variety of crops. Monocultures often increase the number of insect pests, so this would not be a solution for pest management.
(D)	Incorrect. Pesticides are a chemical, not mechanical, means of controlling pests.

Question 70

Skill		Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.		STB-2.A: Identify the sources and effects of air pollutants.	Introduction to Air Pollution
(A)	Incorrect. This describes measures taken under the Resource Conservation and Recovery Act to regulate hazardous solid waste.		
(B)	Incorrect. This describes measures taken under the Kyoto Protocol that provided trade incentives for those countries that met carbon emission reduction goals.		
(C)	Incorrect. This describes measures taken under the Montreal Protocol to decrease ozone-depleting substances in the stratosphere.		
(D)	**Correct.** One of the first major measures taken under the Clean Air Act was to regulate lead in fuels which caused harmful air pollution.		

Question 71

Skill		Learning Objective	Topic
1.B: Explain environmental concepts and processes.		ERT-4.D: Describe the structure and composition of the Earth's atmosphere.	Earth's Atmosphere
(A)	Incorrect. Increased, not decreased, amounts of ozone lead to increased temperatures. Additionally, the ozone layer is found in the stratosphere, not the troposphere.		
(B)	Incorrect. While a less dense atmospheric layer can have a higher temperature, this phenomenon occurs in the thermosphere (even though it would feel cold to humans), not the troposphere. The upper part of the troposphere is less dense than the lower part.		
(C)	**Correct.** The troposphere is the layer of atmosphere closest to Earth and is heated by the Sun's energy, which Earth absorbs and radiates into the air immediately above it.		
(D)	Incorrect. Warm air does rise, but the troposphere is the atmospheric layer closest to Earth and thus is not heated by the energy in the air of any lower atmospheric layers.		

Question 72

Skill		Learning Objective	Topic
7.D: Use data and evidence to support a potential solution.		EIN-2.J: Describe causes of and problems related to overfishing. STB-1.A: Explain the concept of sustainability.	Impacts of Overfishing Introduction to Sustainability
(A)	Incorrect. Decreasing the minimum size limit will allow fishermen to legally catch more orange roughy, decreasing the population further.		
(B)	Incorrect. Further subsidizing the fishermen would encourage greater harvesting of the fish species, which would likely decrease the population further.		
(C)	**Correct.** Based on the data in the graph, the number of orange roughy has had a steady decline in recent years (a result of overfishing practices). Quotas would limit the number caught and allow the population to replenish.		
(D)	Incorrect. Based on the data in the graph, overharvest from fisheries is leading to the change in the population size. Therefore, a fishing practice change would be the best solution to the problem. Additionally, increasing the number of predators would lead to a decrease in the number of orange roughy.		

Question 73

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts. 4.E: Explain modifications to an experimental procedure that will alter results.		STB-3.G: Describe the effects of thermal pollution on aquatic ecosystems.	Thermal Pollution
(A)	**Correct.** As the day goes on, the lake is warmed from the sunlight. Warmer water cannot hold as much dissolved oxygen, so the levels observed later in the day would not be comparable to those observed in the morning.		
(B)	Incorrect. As the day goes on, the lake is warmed from the sunlight. Warmer water cannot hold as much dissolved oxygen, so the levels would likely decrease, not increase.		
(C)	Incorrect. Cellular respiration uses oxygen. A decrease in respiration as a result of macroinvertebrate activity would result in an increase, not decrease, in dissolved oxygen levels.		
(D)	Incorrect. Cellular respiration uses oxygen. An increase in respiration as a result of macroinvertebrate activity would result in a decrease, not increase, in dissolved oxygen levels.		

Question 74

Skill		Learning Objective	Topic
7.B: Describe potential responses or approaches to environmental problems.		STB-1.G: Describe methods for mitigating human impact on forests.	Sustainable Forestry
(A)	Incorrect. Increasing the diversity of trees in an area so they can be harvested is not the most sustainable approach. Additionally, nonnative or invasive species may be economically valuable, but planting those species would not best mitigate deforestation.		
(B)	Incorrect. Native vegetation harvested for agriculture may not include trees or forest species. Agricultural production often requires the removal of tree species.		
(C)	Incorrect. The clearing of more trees only increases the need for mitigation of deforestation. Clear cutting is not considered sustainable forestry practice.		
(D)	**Correct.** Reforestation, or replacing previously deforested areas with similar tree species that have been removed, would best mitigate deforestation.		

Question 75

Skill		Learning Objective	Topic
5.E: Explain what the data implies or illustrates about environmental issues.		STB-4.H: Explain the causes and effects of ocean acidification.	Ocean Acidification
(A)	**Correct.** Anthropogenic activities, such as burning of fossil fuels, vehicle emissions, and deforestation, lead to increased atmospheric CO_2. As more CO_2 is released into the atmosphere, the ocean absorbs part of the excess CO_2 and becomes more acidic.		
(B)	Incorrect. Carbon dioxide released from volcanic eruptions and cellular respiration are considered natural sources of CO_2 and not anthropogenic. Additionally, coral bleaching is linked to increasing ocean temperatures and not to a decrease in pH.		
(C)	Incorrect. Nitrogen oxides (NO_x) are released from a variety of agricultural practices, including at livestock operations. They react to form acid deposition, so an increase in NO_x concentrations would likely lead to an increase in acid deposition in an area.		
(D)	Incorrect. Although a small amount of nitrogen gas may be released from landfills, the primary gases released from decomposition are methane and carbon dioxide. Additionally, the data in the graph do not provide evidence for eutrophication in the ocean.		

Question 76

Skill	Learning Objective	Topic
7.C: Describe disadvantages, advantages, or unintended consequences for potential solutions.	STB-2.G: Explain how air pollutants can be reduced at the source.	Reduction of Air Pollutants

(A)	**Correct.** Coal ash contains toxic levels of several pollutants including arsenic, cadmium, lead, and mercury. This ash is stored in coal ponds near the power plant, which can leak into surrounding aquatic habitats if not properly maintained. The mercury in the ash reacts with chemicals in the ecosystem, forming methylmercury that is very dangerous to the health of all living organisms in the ecosystem.
(B)	Incorrect. Coal ash is the product of coal that has been burned in a power plant as an energy source. It is no longer flammable because all combustible material has already been burned. Coal ash is generally not listed as a fire and explosion hazard.
(C)	Incorrect. An electrostatic precipitator is a filtration device that is designed to remove fine particles, like dust and smoke, from the smokestack. This is an advantage, not a disadvantage, of this method.
(D)	Incorrect. Cost of equipment and filtration are an economic, not environmental, disadvantage to this process.

Question 77

Skill	Learning Objective	Topic
6.C: Calculate an accurate numeric answer with appropriate units.	STB-3.K: Describe solid waste disposal methods.	Solid Waste Disposal

(A)	Incorrect. This is the amount of precipitation that hits the surface of the landfill per year. This calculation does not include the percentage of water that infiltrates the surface of the landfill (80%) nor the efficiency of the leachate collection system (90%).
(B)	**Correct.** This is the amount of precipitation that hits the surface of the landfill per year ($0.3\text{m} / \text{year} \times 6{,}000\text{m}^2 = 1{,}800\text{m}^3$) multiplied by the percentage of water that infiltrates the surface of the landfill ($1{,}800\text{m}^3 \times 80\% = 1{,}440\text{m}^3$), incorporating the efficiency of the leachate collection system ($1{,}440\text{m}^3 \times 90\% = 1{,}296\text{m}^3$).
(C)	Incorrect. This is the amount of precipitation that hits the surface of the landfill per year incorrectly multiplied by the efficiency of the leachate collection system (90%). This calculation does not include the percentage of water that infiltrates the surface of the landfill (80%).
(D)	Incorrect. This is the amount of precipitation that hits the surface of the landfill per year multiplied by the percentage of water that runs off the surface of the landfill (20%). This calculation does not include the percentage of water that infiltrates the surface of the landfill (80%).

Question 78

Skill	Learning Objective	Topic
7.D: Use data and evidence to support a potential solution.	STB-4.A: Explain the importance of stratospheric ozone to life on Earth.	Stratospheric Ozone Depletion

(A)	**Correct.** Based on the data in the graph, the production of CFC-11 in 1978 was nearly 320,000 tons which decreased to approximately 300,000 tons by 1980. The production of CFC-12 decreased from approximately 360,000 tons in 1975 to approximately 320,000 tons in 1980. The decrease in global production in 1980 is linked to the United States ban of CFCs in aerosols.
(B)	Incorrect. Based on the data in the graph, CFC-113 production began in 1980. Although CFC-113 was used as a coolant for refrigerants and air conditioners, the data do not support a 10% increase in global CFC production from 1970 to 1980.
(C)	Incorrect. Based on the data, the production of HCFC-22 increased steadily from 1970 to 2000. HCFC-141b increased steadily from 1990 to 2000. These chemicals, which were created to replace CFCs, still contain chlorine and can lead to stratospheric ozone depletion.
(D)	Incorrect. There are no data in the graph to show an increase in reports of skin cancer and cataracts in the Southern Hemisphere, so this claim is not supported by the data.

Question 79

Skill		Learning Objective	Topic
7.D: Use data and evidence to support a potential solution.		STB-4.A: Explain the importance of stratospheric ozone to life on Earth. STB-4.B: Describe chemicals used to substitute for chlorofluorocarbons (CFCs).	Stratospheric Ozone Depletion Reducing Ozone Depletion
(A)	Incorrect. The Montreal Protocol, finalized in 1987, decreased reliance on CFCs in industrial processes. CFCs are an ozone-depleting substance, not a replacement for one. Although the graph shows an increase in CFC production from 1960 to 1970, this does not demonstrate success of the protocol.		
(B)	Incorrect. The Montreal Protocol was finalized in 1987 as a global agreement. It was not passed as legislation. The goal of the protocol was to phase out the production of CFCs and other ozone-depleting substances, not to increase the production of HCFCs.		
(C)	**Correct.** The Montreal Protocol was finalized in 1987 as a global agreement to phase out the production and consumption of ozone-depleting substances, including CFCs, which break down stratospheric ozone. The data in the graph show a decline in the annual production of CFC-11, CFC-12, and CFC-113, supporting the claim that the Montreal Protocol was an effective solution to decreasing stratospheric ozone depletion.		
(D)	Incorrect. The Montreal Protocol was an agreement to decrease stratospheric ozone depletion, not tropospheric ozone pollution. Additionally, only HCFC-141b has had an annual production of 100,000 tons in 2000; the other substances were produced in higher quantities (HCFC-22 is approximately 200,000 tons) or leveled off near 0 (CFC-11, CFC-12, and CFC-113).		

Question 80

Skill		Learning Objective	Topic
1.C: Explain environmental concepts, processes, or models in applied contexts.		STB-2.J: Describe human activities that result in noise pollution and its effects.	Noise Pollution
(A)	Incorrect. While the noise pollution from the highway is most likely interfering with the bats' echolocation, this would most likely cause them to catch less prey, not more, each night. Also, hunting that is more successful would likely increase, not decrease, the population size of the bats.		
(B)	**Correct.** Since the bats rely on their echolocation ability to locate and catch prey, noise from other sources (in this case, a nearby highway) would most likely interfere with that ability and subsequently reduce their population size because of mortality due to starvation.		
(C)	Incorrect. While all sounds produce sound waves that travel through the air, it is unlikely that noise pollution from a nearby highway would be strong enough to disrupt air-flow patterns and affect the bats' physical ability to fly.		
(D)	Incorrect. It is unlikely that the noise pollution from the highway is attracting more bats to the forest resulting in an increase in intraspecies competition. Also, initially, this would have increased the bats' population size, not decreased it.		

Answer Key and Question Alignment to Course Framework

Multiple-Choice Question	Answer	Skill	Learning Objective	Topic
1	D	1.A	ENG-3.G	Nuclear Power
2	C	1.A	ENG-3.N	Geothermal Energy
3	A	1.A	ENG-3.J	Solar Energy
4	A	2.A	ERT-3.C	Survivorship Curves
5	D	2.A	ERT-3.C	Survivorship Curves
6	C	2.A	ERT-3.C	Survivorship Curves
7	C	2.B	ENG-3.L	Hydroelectric Power
8	D	2.B	ERT-4.A	Plate Tectonics
9	B	2.B	ENG-3.N	Geothermal Energy
10	A	1.C	EIN-2.E EIN-2.F	Irrigation Methods
11	D	1.B	EIN-2.E EIN-2.F	Irrigation Methods
12	C	1.C	EIN-2.F	Irrigation Methods
13	D	1.C	EIN-2.A	The Tragedy of the Commons
14	B	1.B	STB-4.D STB-2.A	Global Climate Change Introduction to Air Pollution
15	A	7.C	EIN-2.G	Pest Control Methods
16	B	2.B	STB-3.B	Human Impacts on Ecosystems
17	B	3.A	ENG-3.K	Solar Energy
18	C	3.B	ENG-3.K	Solar Energy
19	B	3.C	ENG-3.K	Solar Energy
20	D	7.B	ENG-3.J	Solar Energy
21	A	2.B	EIN-1.A	Age Structure Diagrams
22	C	1.A	ERT-2.A	Introduction to Biodiversity
23	B	1.A	ERT-4.D	Earth's Atmosphere
24	B	1.B	STB-2.D	Atmospheric CO2 and Particulates
25	A	1.C	STB-3.D STB-3.C	Endocrine Disruptors
26	C	2.A	EIN-4.C	Human Impacts on Biodiversity
27	C	2.B	EIN-4.C ERT-2.A	Human Impacts on Biodiversity Introduction to Biodiversity
28	B	2.B	EIN-4.C	Human Impacts on Biodiversity

Multiple-Choice Question	Answer	Skill	Learning Objective	Topic
29	A	2.C	EIN-4.C STB-4.E STB-4.F	Human Impacts on Biodiversity Increases in The Greenhouse Gases Global Climate Change
30	B	5.B	ERT-2.F	Ecological Tolerance
31	D	1.B	STB-3.E ERT-2.B	Human Impacts on Wetlands and Mangroves Ecosystem Services
32	A	1.B	ERT-4.D	Earth's Atmosphere
33	D	1.A	ENG-3.J	Solar Energy
34	C	5.A	ERT-1.A ERT-3.F	Introduction to Ecosystems Population Growth and Resource Availability
35	B	5.B	ERT-1.A	Introduction to Ecosystems
36	B	7.C	ERT-1.A	Introduction to Ecosystems
37	D	6.C	EIN-2.M	Impacts of Urbanization
38	C	2.B	STB-1.B	Methods to Reduce Urban Runoff
39	A	2.A	ERT-1.G	The Hydrologic (Water) Cycle
40	C	1.C	ERT-3.B EIN-4.A	K-Selected r-Selected Species Invasive Species
41	C	1.B	ENG-3.B ENG-3.C	Global Energy Consumption Fuel Types and Uses
42	B	1.C	STB-4.F	Global Climate Change
43	D	7.B	ERT-4.B	Soil Formation and Erosion
44	A	6.C	EIN-1.C	Human Population Dynamics
45	C	6.A	EIN-1.C	Human Population Dynamics
46	B	6.A	EIN-1.C	Human Population Dynamics
47	D	1.C	ENG-2.A	Solar Radiation and Earth's Seasons
48	C	7.C	EIN-2.I	Meat Production Methods
49	C	1.B	STB-2.B	Photochemical Smog
50	B	2.A	ERT-2.I	Ecological Succession
51	B	2.B	ERT-2.I ERT-2.J	Ecological Succession
52	B	1.B	ERT-2.I	Ecological Succession
53	A	3.A	EIN-4.C	Human Impacts on Biodiversity
54	B	3.B	EIN-4.C	Human Impacts on Biodiversity
55	C	3.C	EIN-4.C	Human Impacts on Biodiversity

Multiple-Choice Question	Answer	Skill	Learning Objective	Topic
56	C	1.C	STB-2.I	Acid Rain
57	C	1.A	EIN-1.C	Human Population Dynamics
58	A	4.A	STB-4.H	Ocean Acidification
59	B	5.D	EIN-4.A	Invasive Species
60	C	1.C	EIN-3.A	Lethal Dose 50% (LD50)
61	D	1.C	EIN-4.A	Invasive Species
62	C	7.B	ERT-4.C	Soil Composition and Properties
63	B	7.C	STB-2.H	Acid Rain
64	A	1.C	STB-3.B	Human Impacts on Ecosystems
65	B	5.C	ENG-2.A	Solar Radiation and Earth's Seasons
66	C	5.C	ENG-1.A	Primary Productivity
67	C	5.C	ERT-1.B	Terrestrial Biomes
68	D	6.A	EIN-2.J	Impacts of Overfishing
69	B	7.B	STB-1.C	Integrated Pest Management
70	D	7.B	STB-2.A	Introduction to Air Pollution
71	C	1.B	ERT-4.D	Earth's Atmosphere
72	C	7.D	EIN-2.J STB-1.A	Impacts of Overfishing Introduction to Sustainability
73	A	1.C	STB-3.G	Thermal Pollution
74	D	7.B	STB-1.G	Sustainable Forestry
75	A	5.E	STB-4.H	Ocean Acidification
76	A	7.C	STB-2.G	Reduction of Air Pollutants
77	B	6.C	STB-3.K	Solid Waste Disposal
78	A	7.D	STB-4.A	Stratospheric Ozone Depletion
79	C	7.D	STB-4.A STB-4.B	Stratospheric Ozone Depletion Reducing Ozone Depletion
80	B	1.C	STB-2.J	Noise Pollution

Free-Response Section

Scoring Guidelines

Question 1: Design an Investigation — 10 points

Learning Objectives: ERT-1.D STB-3.G STB-4.H

General Scoring Note:
When scoring questions with multiple correct answers, only score the first response given.

(A) The diagram below shows the cycling of carbon.

(i) **Identify** a process shown in the diagram that removes carbon from the atmosphere. — **1 point** 2.A ERT-1.D

Accept one of the following:

- The Photosynthesis
- Absorption of CO_2 into ocean

(ii) **Identify** a process shown in the diagram that sequesters carbon from the atmosphere for a geological period of time. — **1 point** 2.B ERT-1.D

Accept one of the following:

- Formation of fossil fuels (coal, oil, and gas)
- Formation of limestone from sediments in the ocean

(iii) Based on the diagram, **explain** how the combustion of fossil fuels has led to an imbalance in the carbon cycle. — **1 point** 2.C ERT-1.D

Accept one of the following:

- Carbon that was sequestered in coal, oil, or natural gas is combusted and increases the amount of carbon dioxide in the atmosphere.
- Excess carbon is released into the atmosphere from anthropogenic sources, not natural sources, leading to carbon dioxide concentrations that increase faster than can be removed through photosynthesis/absorption into the ocean.

(iv) **Explain** the role of decomposition in the carbon cycle. — **1 point** 1.A ERT-1.D

Accept one of the following:

- Decomposers cycle carbon from tissue/biomass of dead or decaying organisms into the atmosphere or water as released CO_2 from aerobic decomposition. (Anaerobic decomposition releases CH_4 into the atmosphere).
- Decomposers convert organic material ($C_6H_{12}O_6$) into CO_2 during aerobic respiration.
- Decomposers convert organic material ($C_6H_{12}O_6$) into CH_4 during anaerobic respiration.

Total for part (A) **4 points**

(B) Scientists are interested in researching how carbon dioxide in the oceans affects their pH. They design a laboratory experiment in which they inject different concentrations of carbon dioxide into saltwater tanks containing calcium carbonate shells. The tanks are kept at the same, constant temperature. After several days, the scientists measure the pH of the saltwater tanks and observe its effects on the calcium carbonate shells.

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

4.B

STB-4.H

Accept one of the following:

- Concentration of CO_2
- Amount of CO_2 injected into the saltwater tanks

(ii) **Describe** a control group that could be used in this experiment. **1 point**

4.C

STB-4.H

Accept one of the following:

- The pH of the tanks before different concentrations of carbon dioxide were injected (the baseline pH)
- A tank kept at the same, constant temperature with no carbon dioxide injected

(iii) **Explain** the effect of carbon dioxide on the pH of the oceans. **1 point**

1.C

STB-4.H

Accept one of the following:

- Increased CO_2 dissolves in oceans, leading to formation of carbonic acid, decreasing the pH of the water/increasing acidification.
- Additional CO_2 in the ocean disrupts the carbonate buffering system and the ocean becomes more acidic/the pH of the ocean decreases.

(iv) **Describe** the effect of water temperature on the amount of dissolved gases in water. **1 point**

1.B

STB-3.G

Accept one of the following:

- As water temperature increases, the amount of dissolved oxygen (DO) decreases.
- As water temperature decreases, the amount of dissolved oxygen (DO) increases.
- Gases become less soluble in water as the temperature of the liquid decreases.

(v) **Describe** how the results of the experiment would change if the temperature of the tanks was decreased. **1 point**

4.E

STB-3.G

STB-4.H

- More CO_2 would have dissolved in tanks, which would increase acidification/ decrease in pH/cause a larger observed pH change.

(vi)	**Describe** how a decrease in ocean pH can affect marine organisms. **Accept one of the following:** • A decrease in pH can cause the calcium carbonate shells of marine organisms to become weak or thin and break easily. • A decrease in pH will make it harder for mollusks to form their shells. • A decrease in pH will make it harder for corals to form their exoskeletons. • An increase in acidity/decrease in pH may be outside the range of ecological tolerance for many species and could cause a population decline. • A decrease in pH can negatively affect the ability of marine organism to maintain homeostasis.	**1 point** 7.A STB-4.H
	Total for part (B)	**6 points**
	Total for question 1	**10 points**

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

Learning Objectives: STB-3.N STB-3.F EIN-3.D STB-3.K STB-3.M ENG-3.E

General Scoring Note:
When scoring questions with multiple correct answers, only score the first response given.

The waste generated by humans is both an environmental and human health concern.

(A) Many countries now use centralized sewage treatment plants to treat the wastewater from houses and businesses.

(i) **Describe** a main goal of primary treatment in a modern sewage treatment plant. — **1 point** 1.A STB-3.N

Accept one of the following:

- Large debris/solid waste is physically separated from wastewater using screens/grates/other means.
- Sludge/solid waste settles out in tanks.

(ii) **Describe** a main goal of secondary treatment in a modern sewage treatment plant. — **1 point** 1.A STB-3.N

Accept one of the following:

- Microbes (bacteria, fungi, viruses, etc.) are used to break down organic matter.
- Aeration in the sludge tank aids microbes in the breakdown of organic matter.

(iii) Many sewage treatment plants use tertiary treatment as the final step in wastewater treatment. **Describe** one advantage of this process. — **1 point** 7.C STB-3.N

Accept one of the following:

- Kills most microbes, including pathogens, decreasing the spread of disease in humans
- Removes nutrients like phosphorus and nitrogen, decreasing the amount of nutrients in surface waters/reducing the potential for algal blooms

(iv) If a sewage treatment plant malfunctions or if low-income areas lack sanitary waste disposal, raw sewage can be introduced into surface waterways. **Describe** one potential environmental problem or one potential human health problem that can result from the presence of raw sewage in surface waters. — **1 point** 7.A STB-3.F EIN-3.D

Accept one of the following:

- Environmental problem: Eutrophication from excess nutrients in water with sewage overflow, decreases dissolved oxygen levels in water as decomposers respire while breaking down waste (which stresses or kills aquatic organisms, such as fish)
- Human health problem: Disease-causing organisms/pathogens introduced to surface water could be consumed in drinking water and spread infectious disease (such as cholera, hepatitis A, gastroenteritis, giardia)

(v)	**Identify** one water parameter that could be measured to determine whether raw sewage is present in surface waterways. **Accept one of the following:** • Fecal coliform test • A test for density of fecal coliform bacteria which, while generally harmless, live in human intestines and indicate potential for disease-causing organisms. • A test for disease-causing organisms, such as bacteria or viruses, in water • Dissolved oxygen (DO) test • Biological oxygen demand (BOD) test • Turbidity • Conductivity • Total suspended solids (TSS) • A test that measures the amount of oxygen a quantity of water uses over a period of time at a specific temperature	**1 point** 7.B STB-3.F EIN-3.D
	Total for part (A)	**5 points**
(B)	The United States Environmental Protection Agency (EPA) refers to the trash or garbage that can be placed in landfills (landfilled) as municipal solid waste (MSW). MSW can include such items as bottles, cardboard boxes, food, grass clippings, furniture, tires, computers, and appliances. The total MSW generated and the total MSW landfilled from 1960 to 2015 in the United States are shown in the graph below.	
(i)	**Describe** the trend in total MSW generated from 1960 to 2015. **Accept one of the following:** • The total MSW generated increased. • The total MSW generated increased, with a brief leveling off between about 2005 and 2010.	**1 point** 5.A STB-3.K
(ii)	**Compare** the trends in the total MSW generated and the total MSW landfilled between 1990 and 2000. **Accept one of the following:** • The total MSW generated increased between 1990 and 2000, but the total MSW sent to landfills decreased slightly during that same period. • The total MSW generated increased between 1990 and 2000, but the total MSW sent to landfills remained nearly the same during that period.	**1 point** 5.B STB-3.K
(iii)	Explain a probable reason for the trend in the total MSW landfilled described in (b)(ii). **Accept one of the following:** • Increased programs to increase the tonnage of MSW recycled, reused, or reduced through conservation measures were instituted after 1990. • Programs to increase the tonnage of MSW composted increased after 1990. • Programs to increase the tonnage of MSW burned to produce electricity increased after 1990.	**1 point** 5.E STB-3.M
	Total for part (B)	**3 points**

(C) One environmental problem in landfills is that organic materials such as food scraps and yard waste can decompose and produce methane over time. Methane is flammable and can be very dangerous in large concentrations.

(i) **Propose** a solution to reduce the risk of flammable methane from concentrating in landfills. **1 point** 7.E ENG-3.E STB-3.M

Accept one of the following:

- Flare/burn the methane from venting and release by products into the air
- Collect the methane (to use as fuel) and burn it to power turbines for electricity generation.
- Incinerate all organic material instead of sending it to a landfill.
- Compost all organic material instead of sending it to a landfill.

(ii) **Justify** your solution proposed in (c)(i) by explaining an additional benefit to the solution besides reducing the amount of flammable methane concentrating in the landfill. **1 point** 7.F ENG-3.E STB-3.M

Accept one of the following justifications.

Solution proposed in (c)i.	Justification of Solution with an Additional Benefit
Flare/burn the methane from venting and release by products into the air	• Can reduce the release of methane (a potent greenhouse gas) into the atmosphere
Collect the methane (to use as fuel) and burn it to power turbines for electricity generation.	• Produce energy/generate electricity for personal or consumer use (economic benefit) • Capture methane to reduce the release of methane (a potent greenhouse gas) into the atmosphere • Decrease reliance on coal and other fossil fuels that must be extracted for electricity generation
Incinerate all organic material instead of sending it to a landfill.	• Produce energy/generate electricity for personal or consumer use (economic benefit)
Compost all organic material instead of sending it to a landfill.	• Use of compost for organic fertilizer for personal or consumer use (ecological or economic benefit) • Reduce need for synthetic fertilizers in farming by using compost

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

Learning Objectives: STB-1.E EIN-1.C STB-1.A

(A) Preserving high-quality agricultural land is important so that countries can grow enough food to feed their populations.

(i) **Describe** one agricultural practice that can lead to the degradation of agricultural land. — **1 point** 7.A STB-1.E

Accept one of the following:

- Plowing/tilling the soil increases soil erosion (by breaking up the soil structure) and reduces fertility
- Using monocultures/growing only one crop over and over will deplete the soil of nutrients
- Clearing a field to plant crops can lead to soil desiccation
- Overgrazing by livestock leads to a loss of soil cover and increases soil erosion
- Concentrated animal feedlots (CAFOs) can lead to compaction of soil from animals on grasslands
- Leaving a field fallow, without a cover crop, can lead to desiccation.

(ii) **Describe** a potential solution or technique that can prevent or reduce degradation of agricultural land. — **1 point** 7.B STB-1.E

Accept one of the following:

- Contour plowing uses the contours of the land to minimize soil erosion.
- Terracing, growing crops on the side of hills or mountains in a number of flat areas like a series of steps, reduces soil erosion.
- Windbreaks use one or more rows of trees/shrubs to protect an area from wind, which reduces soil erosion.
- Perennial crops remain in the soil year-round/can survive several years, which reduces the need for replanting and improves structure of the soil/ reduces erosion
- Cover crops/green manures are grown to protect and enrich the soil/improve soil properties and prevent erosion
- No-till agriculture/zero till agriculture does not disturb the soil increasing the retention of organic matter/decreases soil erosion/helps retain water in soil
- Strip cropping uses different crops in alternate strips to prevent soil erosion
- Crop rotation uses a series of different types of crops in the same area over seasons to prevent a loss of soil nutrients/to increase soil fertility and decrease erosion
- Polycultures uses a series of different types of crops grown at the same time to increase diversity using less land and decreasing wastes
- Addition of green manure, compost, limestone, and /or sulfur helps to retain soil moisture and increase organic material in soil

- Rotational grazing involves moving animals through a series of pastures, which benefits the grasses in the pastures/decreases soil compaction/ increases soil fertility
- Free-range livestock operations often use diverse grasses to feed animals, which improve soil quality. If animals are moved from area to area, they can fertilizer the area with manure.
- Agroforestry incorporates the cultivation of trees with agriculture that improves soil quality and decreases erosion

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

(B) A less developed country with a rapidly expanding urban population is concerned that its growing urban population will eventually expand to a level where there would not be enough land to grow the food it needs to support its population.

(i) Excluding importing food, **propose** a solution to address the concerns of reduced land on which to grow food. **1 point** 7.E EIN-1.C

Accept one of the following:

- Improve yields per hectare through use of genetically modified (GM) crops/ high-yield crops/technology, etc.
- Plant rooftop gardens in urban areas.
- Use vertical farming techniques
- Grow only crops for food, since plants produce more kilocalories per hectare than livestock.
- Build up, not out, in urban areas/require high density buildings in urban areas.
- Reduce population growth by family planning, etc.

(ii) For your solution in (b)(i), **explain** an additional potential advantage of the solution. **1 point** 7.F STB-1.A

Accept any of the following additional advantages:

Solution proposed in (b)i.	Additional Potential Advantage of Solution
Improve yields per hectare through use of genetically modified (GM) crops/ high-yield crops/technology, etc.	• Can preserve remaining habitat for biodiversity • Reduced use of pesticides/ herbicides • Reduced water requirements

Plant rooftop gardens in urban areas.	• Can preserve remaining habitat for biodiversity • Can insulate buildings • Can reduce stormwater runoff • Can offset heat island effect • Provides green space for urban dwellers • Can grow crops on existing buildings so no additional land is required • Can produce food for human consumption/Can sell crops for profit
Use vertical farming techniques	• Can allow for similar crop yield in a smaller footprint
Grow only crops for food, since plants produce more kilocalories per hectare than livestock.	• Can preserve remaining habitat for biodiversity • Reduced pollution of waterways with livestock waste because of elimination/reduction of livestock • Reduced methane emissions because of elimination/reduction of livestock
Build up, not out, in urban areas/require high density buildings in urban areas.	• Can preserve remaining habitat for biodiversity • Can lower ecological footprint of individuals because of reduced transportation, etc.
Reduce population growth by family planning, etc.	• Can preserve remaining habitat for biodiversity • Reduced greenhouse gas emission, reduced resource extraction, etc. because of reduced population growth
	Total for part (B) 2 points

(C) A table for the population size in the country is shown below.

(i) Based on the table, **calculate** the percent change of the population size in this country between 2009 and 2017. **Show** your work. **2 points** 6.B 6.C EIN-1.C

1 point for correct setup to calculate the percent change of the population size

$$\frac{(4.6 - 2.7)}{2.7} \times 100$$

1 point for the correct calculation of the percent change of the population size

$$= 70.37\%$$

percent change $= 70.4\%$

$$= 70\%$$

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

(D) An average person in the country needs 2,450 kilocalories (kcal)/day of food to meet their full nutritional needs. The average number of kcal per hectare (ha) produced from available food in the country is 15,737,000 kcal/ha.

(i) **Calculate** the amount of land that would be needed to produce enough kilocalories to feed a person for one year in this developing country. **Show** your work. **2 points** 6.B 6.C EIN-1.C

1 point for the correct setup to calculate the amount of land

$$\frac{2.45 \times 10^3 \text{ kcal/person}}{\text{day}} \times \frac{3.65 \times 10^2 \text{ days}}{1 \text{ year}} \times \frac{1 \text{ ha}}{1.5737 \times 10^7 \text{ kcal}}$$

1 point for the correct calculation of the amount of land

$$\text{amount of land} = \frac{0.0568 \text{ ha/person}}{\text{year}}$$

$$= \frac{5.68 \times 10^{-2} \text{ ha/person}}{\text{year}}$$

(ii) **Calculate** how much land would have been needed to feed the population of this country in 2017. **Show** your work. **2 points** 6.B 6.C EIN-1.C

1 point for the correct setup to calculate the amount of land needed in 2017

$$4.6 \times 10^6 \text{ people} \times \frac{5.68 \times 10^{-2} \text{ ha/person}}{\text{year}}$$

1 point for the correct calculation of the amount of land needed in 2017

$$\text{amount of land} = 2.614 \times 10^5 \text{ ha}$$

$$= 261{,}400 \text{ ha}$$

NOTE: If the student did not correctly calculate part (d)(i), the response for part (d)(ii) can earn points if the incorrect values were used correctly in the equations in part (d)(ii).

Total for part (D) **4 points**

Total for question 3 **10 points**

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