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

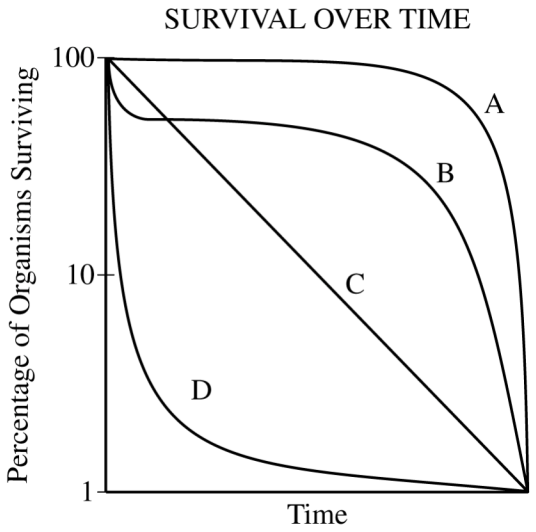
1. This type of energy is considered a nonrenewable energy source.

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.

GO ON TO THE NEXT PAGE.

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?

GO ON TO THE NEXT PAGE.

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.

GO ON TO THE NEXT PAGE.

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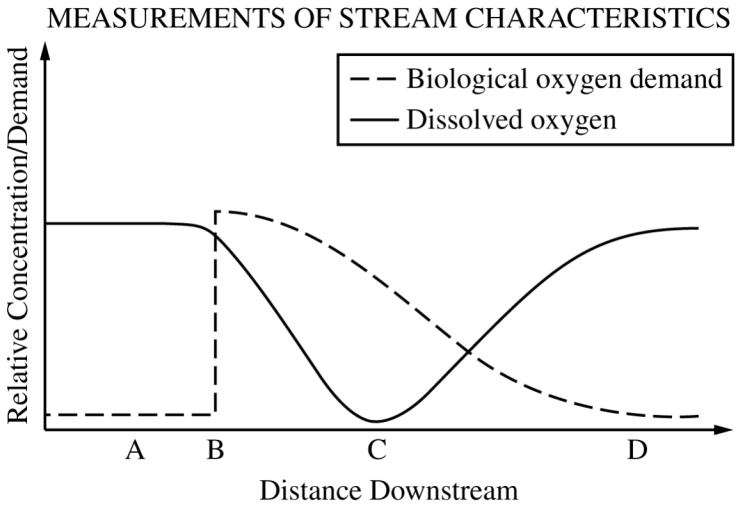
16. The graph shows how biological oxygen demand (BOD) and dissolved oxygen (DO) concentration change over the length of a stream. Points A–D indicate different locations within the stream.



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

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GO ON TO THE NEXT 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

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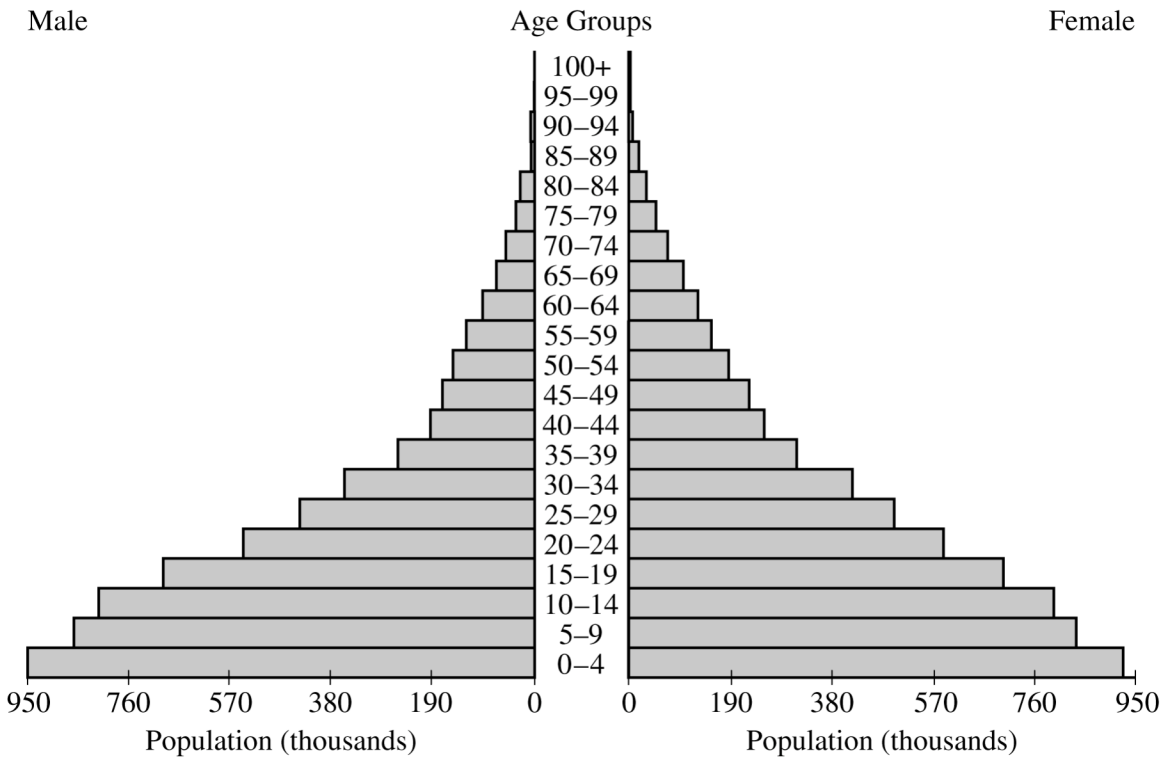

21. Based on the diagram, this country is likely experiencing

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

GO ON TO THE NEXT PAGE.

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

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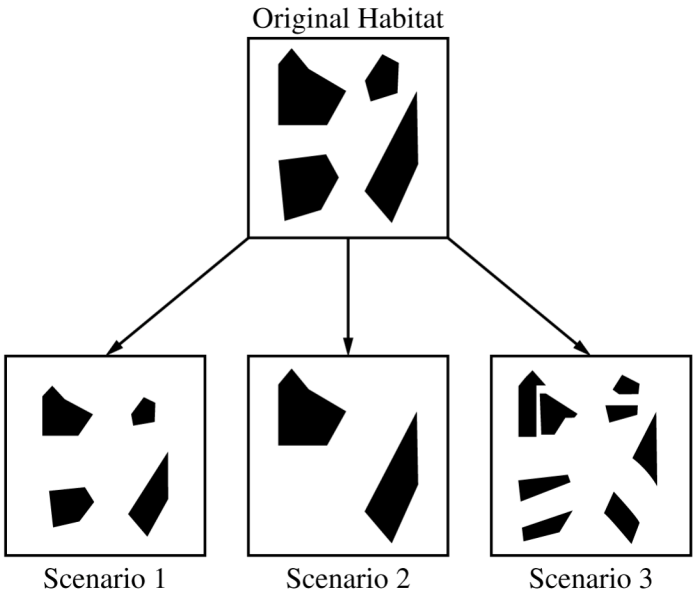
Questions 26 - 29 refer to the diagram below.

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

GO ON TO THE NEXT PAGE.

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.

GO ON TO THE NEXT PAGE.

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.

GO ON TO THE NEXT PAGE.

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

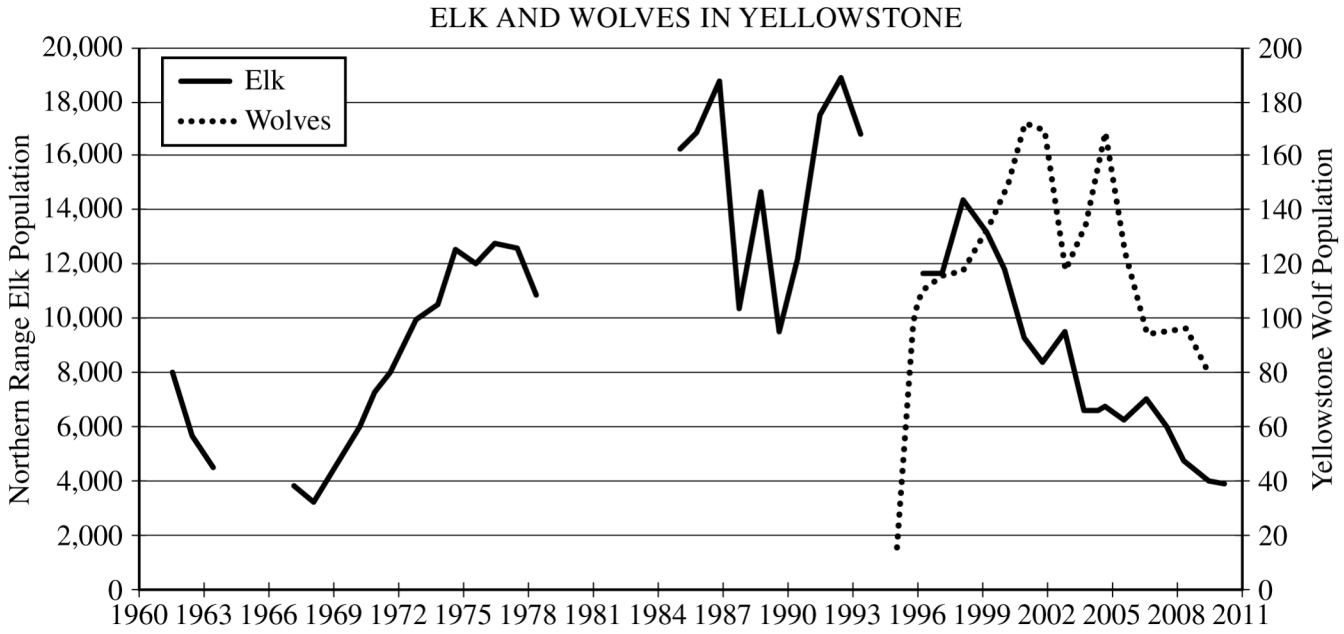
33. Buildings designed to partially heat rooms by passive solar heating rely on

(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

GO ON TO THE NEXT PAGE.

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.

GO ON TO THE NEXT PAGE.

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.

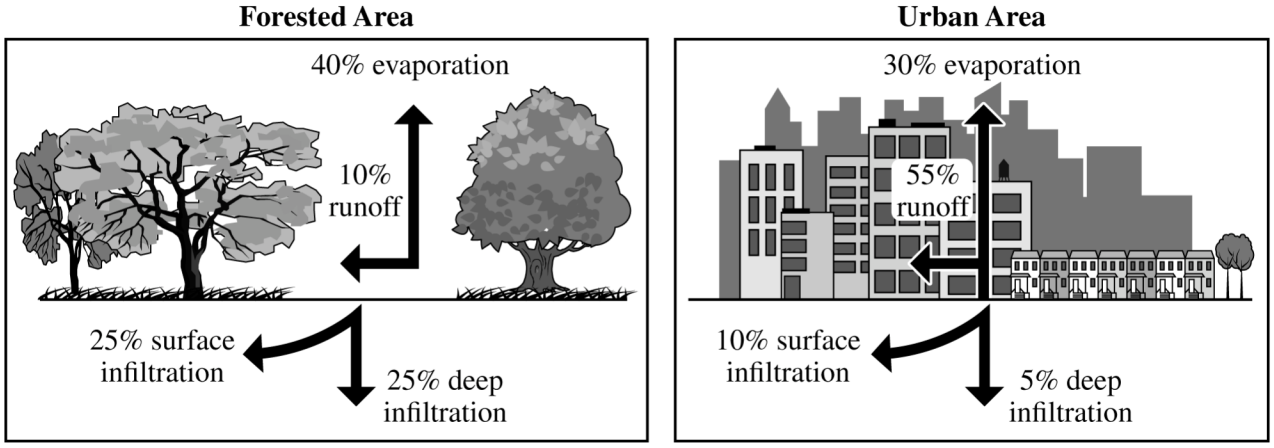
(B) Wolves leaving the park may prey on livestock in grazing land outside the park.

(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.

GO ON TO THE NEXT PAGE.

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

GO ON TO THE NEXT PAGE.

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

GO ON TO THE NEXT PAGE.

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) $\dfrac{11.9}{17.6} \times 100$

GO ON TO THE NEXT PAGE.

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

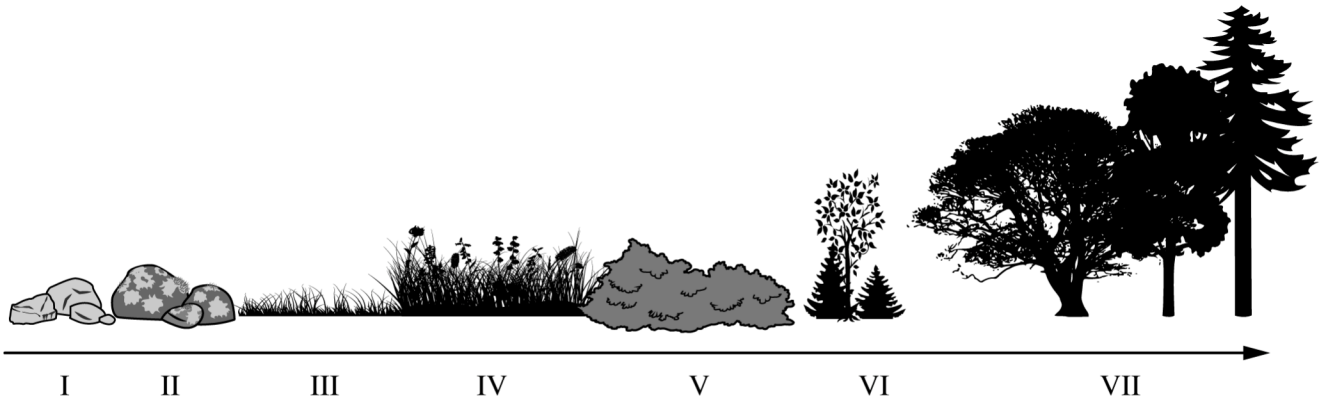
(C) NO_x and UV light

(D) UV light and CO_2

GO ON TO THE NEXT PAGE.

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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GO ON TO THE NEXT PAGE.

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.

GO ON TO THE NEXT PAGE.

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?

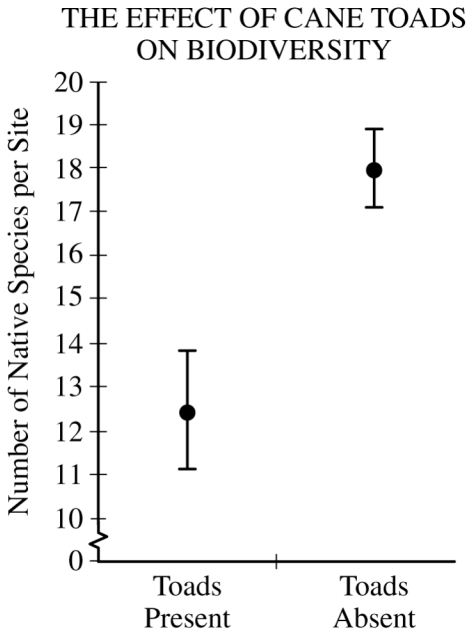
(A) Competition for resources like food and water
(B) Infectious disease transmission
(C) Occurrences of droughts and flooding
(D) Reduced availability of habitat

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.

GO ON TO THE NEXT PAGE.

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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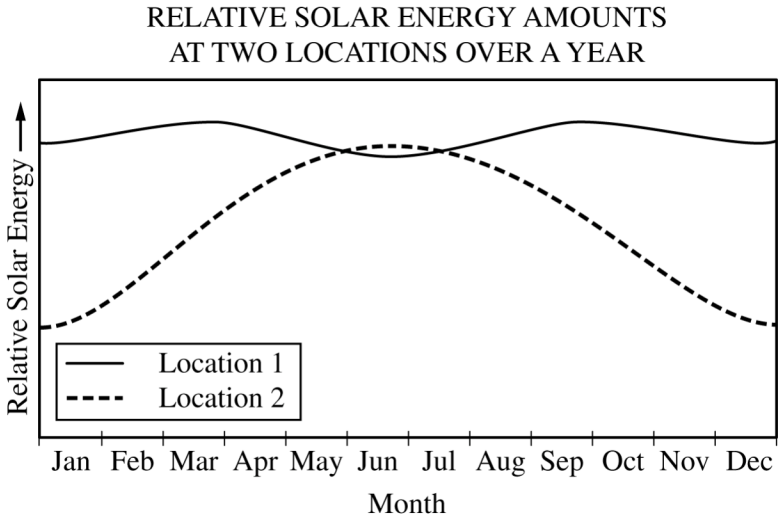
Questions 65 - 67 refer to the graph below.

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

GO ON TO THE NEXT PAGE.

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.

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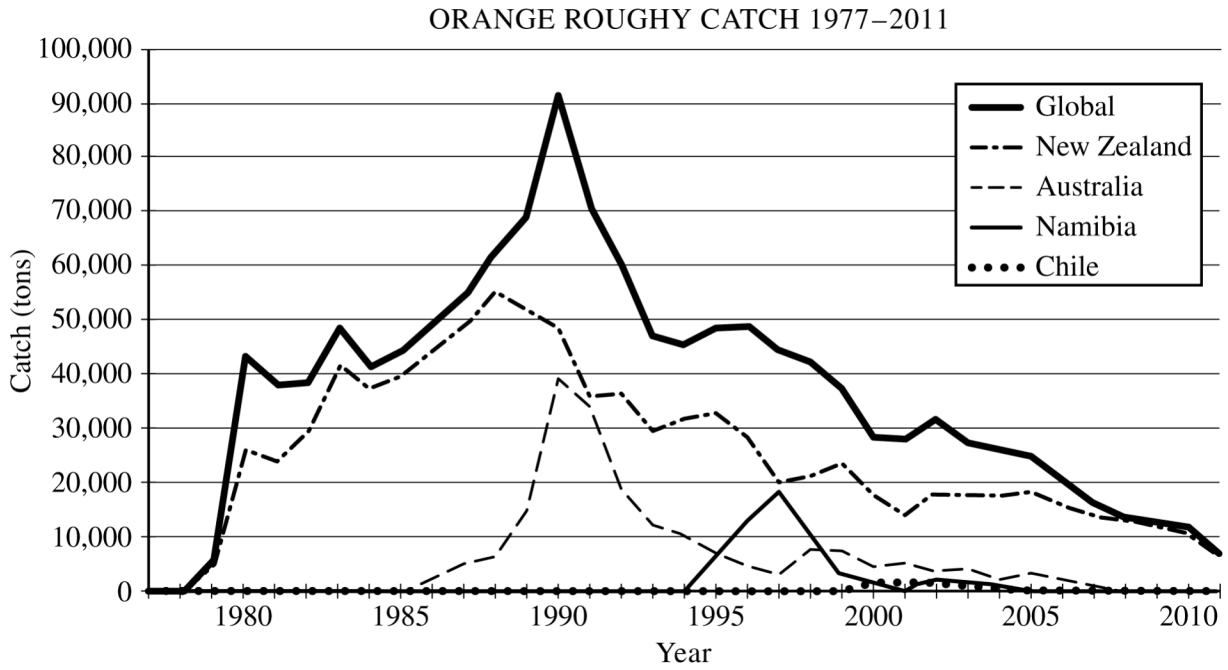

72. The graph shows the worldwide catch of orange roughy, a type of wild caught fish, in tons, from 1977 to 2011.

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

GO ON TO THE NEXT PAGE.

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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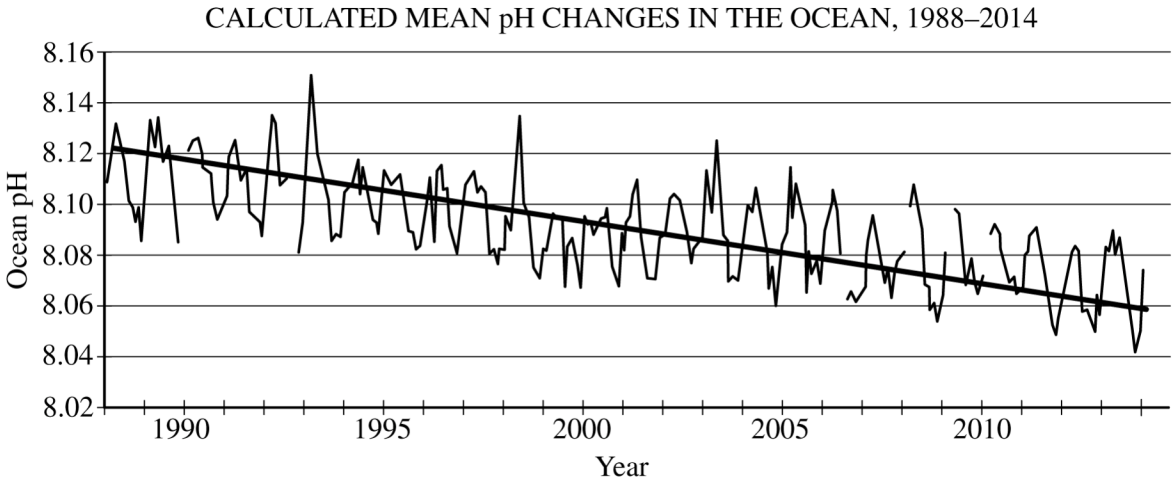

75. Which of the following best explains an anthropogenic cause of the trend illustrated on the graph?

(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.

GO ON TO THE NEXT PAGE.

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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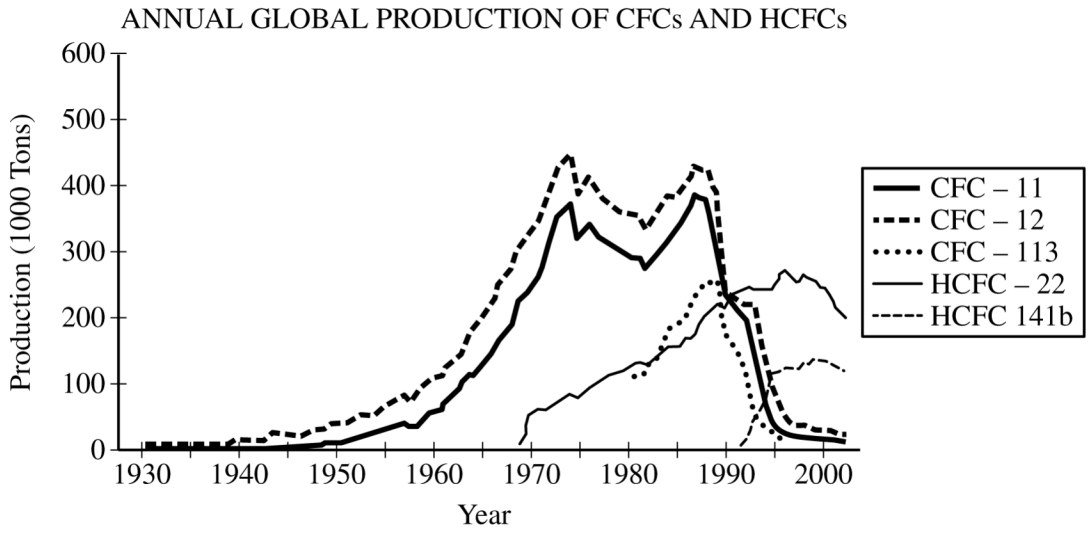
Questions 78 and 79 refer to the graph below.



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.

GO ON TO THE NEXT PAGE.

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.

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

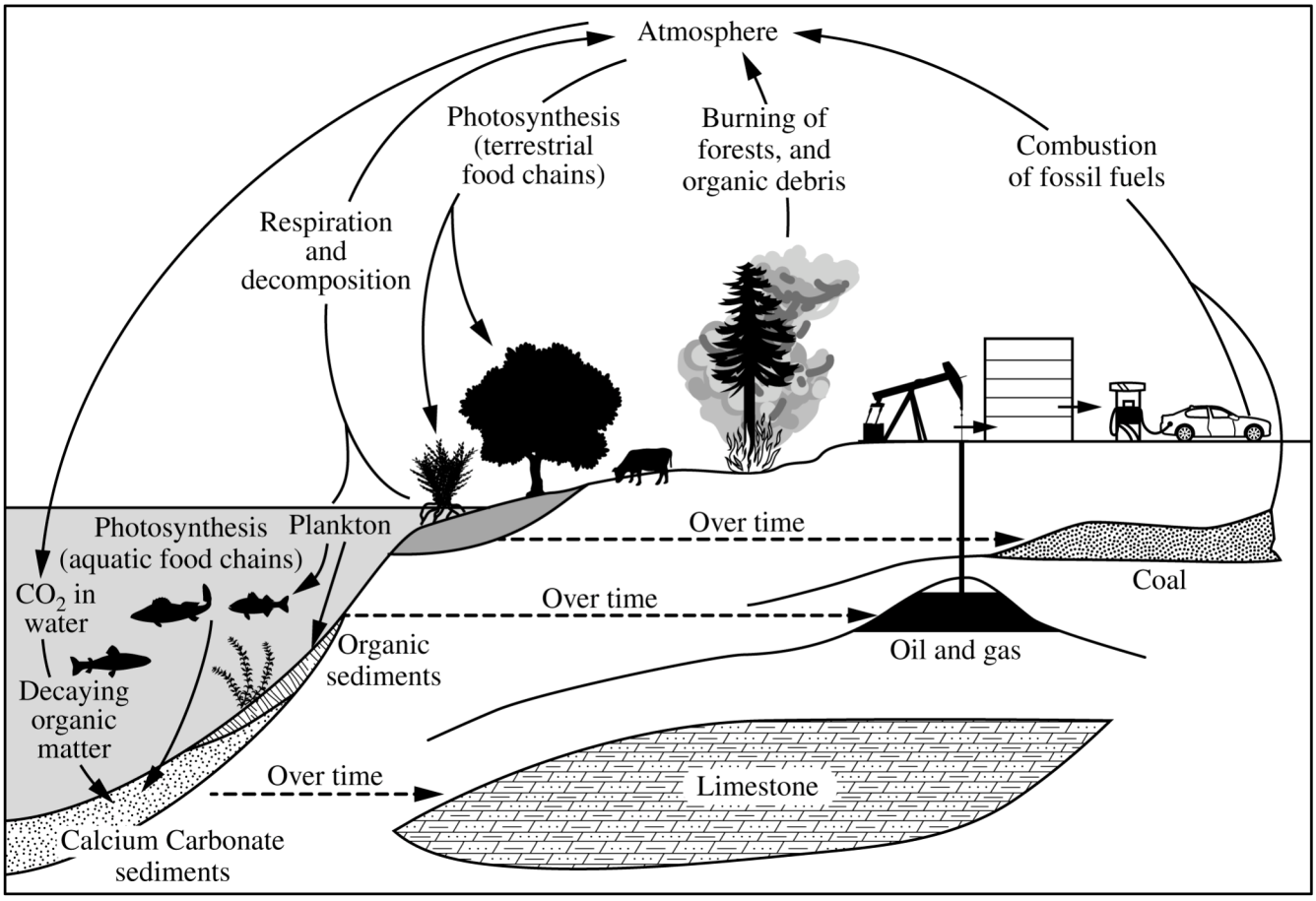
SECTION II

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.

GO ON TO THE NEXT PAGE.

ANSWER PAGE FOR QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

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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.

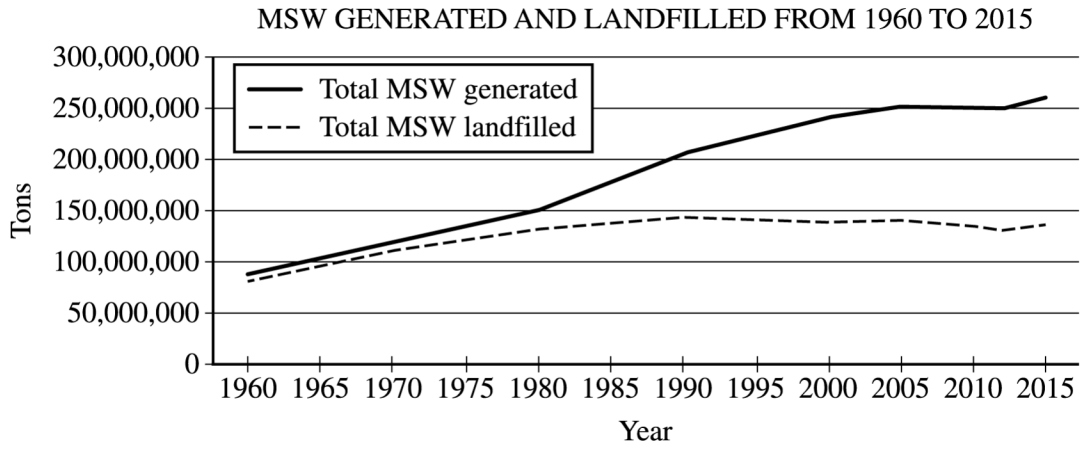
(ii) Describe a main goal of secondary treatment in a modern sewage treatment plant.

(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.

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ANSWER PAGE FOR QUESTION 3

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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**