ENVIRONMENTAL SCIENCE

A total of three hours is allotted for this examination; 90 minutes for Section I, which consists of 100 multiple-choice questions, and 90 minutes for Section II, which consists of 4 free-response questions. Section I is printed in this examination booklet. Section II is printed in a separate booklet.

NO CALCULATORS MAY BE USED IN THIS SECTION OR IN SECTION II OF THE EXAMINATION.

SECTION I

Time — 1 hour and 30 minutes

Number of questions — 100

Percent of total grade — 60

This section of the examination contains 100 multiple-choice questions, followed by 9 multiple-choice questions regarding your preparation for this examination. Therefore, please be careful to fill in only the ovals that are preceded by numbers 1 through 109 on your answer sheet. NO CALCULATORS ARE ALLOWED.

General Instructions

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

INDICATE ALL YOUR ANSWERS TO QUESTIONS IN SECTION I ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination booklet, but you may use the booklet for notes or scratchwork. After you have decided which of the suggested answers is best, COMPLETELY fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely.

Example:

Chicago is a

(A) state
(B) city
(C) country
(D) continent
(E) village

Sample Answer

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. In this section of the examination, as a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly will be subtracted from the number of questions you answer correctly. It is improbable, therefore, that mere guessing will improve your score significantly; it may even lower your score, and it does take time. If, however, you are not sure of the correct answer but have some knowledge of the question and are able to eliminate one or more of the answer choices as wrong, your chance of getting the right answer is improved, and it may be to your advantage to answer such a question.

Use your time effectively, working as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult. Go on to other questions and come back to the difficult ones later if you have time. It is not expected that everyone will be able to answer all the multiple-choice questions.

ENVIRONMENTAL SCIENCE

Section I

Time—1 hour and 30 minutes

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 questions or best fits each statement and then fill in the corresponding oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-4 refer to the following methods of solid-waste disposal and treatment.

(A) Sanitary landfill
(B) Incineration
(C) Discharge to sewers, streams, and rivers
(D) Chemical treatment
(E) Biological treatment

1. Which method reduces the volume of waste but could release toxic emissions into the atmosphere?
2. Which method is used most frequently in the United States today?
3. Which method introduces microorganisms to break down hazardous organic compounds?
4. Which method would be best suited for neutralizing the acidic components of waste?

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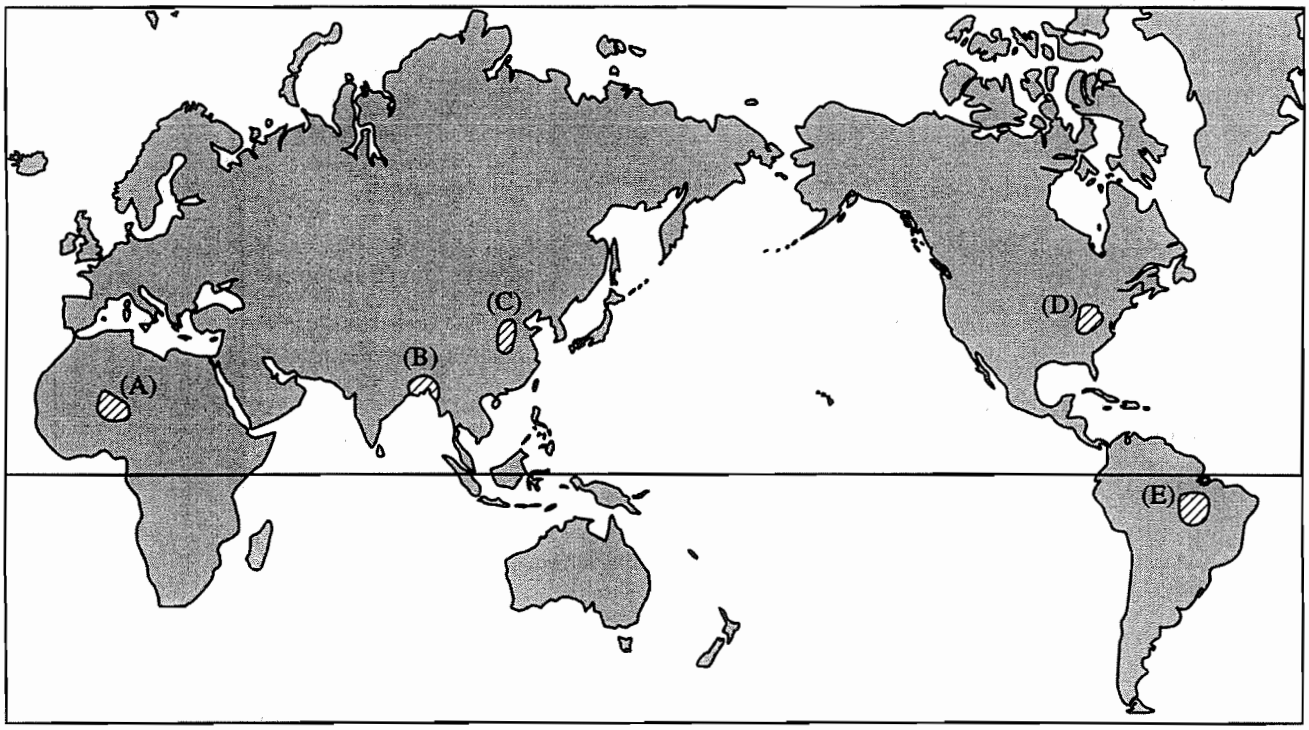
Questions 5-8 refer to the locations marked by letters in the world map below.



5. The location where the greatest number of people would be directly affected by a rise in ocean level
6. The location of the greatest remaining natural biodiversity
7. The location where desertification is occurring most rapidly
8. The location where the size of the human population is the most stable

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Questions 9-12 refer to the following possible relationships between organisms in an ecosystem.

(A) Commensalism
(B) Parasitism
(C) Mutualism
(D) Predation
(E) Competition

9. Exemplified by ticks feeding on a deer
10. Exemplified by starlings displacing bluebirds from nesting sites
11. Exemplified by bees consuming nectar and carrying pollen from one flower to another
12. Exemplified by moss growing on a tree trunk in a forest

Questions 13-16 refer to the following concepts related to energy.

(A) Heat flow
(B) Kinetic energy
(C) Potential energy
(D) First law of thermodynamics
(E) Second law of thermodynamics

13. Matter in motion has energy.
14. Energy is transferred from one object to another as the result of a temperature difference.
15. An energy transformation occurs and results in increased disorder.
16. The amount of energy in an isolated system stays constant.

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Questions 17-20 refer to the following energy sources.

(A) Biomass
(B) Wind
(C) Tidal energy
(D) Nuclear fission
(E) Sunlight

17. The source that produces long-lived hazardous wastes
18. The source that is converted directly into electrical energy by photovoltaic cells
19. The source whose use is a direct cause of deforestation
20. The source that is not renewable

Questions 21-24 refer to the following qualities of water samples.

(A) Acidity
(B) Turbidity
(C) Hardness
(D) Dissolved oxygen
(E) Salinity

21. Measured on the pH scale
22. Caused by suspended particulates
23. Decreased by the breakdown of organic waste
24. Measured by the amount of Ca^{2+} and Mg^{2+}

Questions 25-28 refer to the following gases.

(A) Carbon dioxide
(B) Carbon monoxide
(C) Methane
(D) Radon
(E) Sulfur dioxide

25. Is an important precursor to acid rain
26. Has a stronger affinity for hemoglobin than oxygen has
27. Has been implicated as the cause of as much as 15 percent of lung cancer cases
28. Is a flammable gas produced by landfills

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Part B

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

29. Ozone in the stratosphere is important to organisms at Earth's surface because ozone molecules are very strong absorbers of

(A) infrared rays
(B) ultraviolet rays
(C) microwaves
(D) visible light rays
(E) x-rays

30. Reasons that human populations historically have settled in floodplains include which of the following?

I. The soil in floodplains is usually fertile.
II. The terrain in floodplains tends to be flat.
III. Floodplains are close to rivers for transportation.

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

31. The National Environmental Policy Act (NEPA) of 1969 required all agencies responsible for a major federal project that could significantly affect the quality of the environment to file which of the following?

(A) A mitigated negative declaration
(B) A geographic information system report
(C) An environmental impact statement
(D) An agency review
(E) A cost-benefit analysis

32. All of the following are considered toxic metal pollutants EXCEPT

(A) cadmium
(B) chromium
(C) lead
(D) mercury
(E) potassium

33. Which of the following actions would be the most effective in decreasing acid rain and acid deposition problems?

(A) Using higher smokestacks
(B) Reducing use of fossil fuels
(C) Developing acid-resistant crops
(D) Adding lime to acidified lakes
(E) Relocating power plants to areas of lower population density

34. In general, which of the following is the best long-term method of preventing extinctions?

(A) Breeding endangered species in captivity
(B) Protecting the habitats of endangered species
(C) Paying people not to kill endangered species
(D) Providing food to endangered species in the wild
(E) Removing predators from areas that contain endangered species

35. Which of the following is most likely to occur in a forested region that has been recently clear-cut?

(A) The concentration of nitrates in streams running through the region will increase.
(B) The average depth of topsoil will increase.
(C) The water temperature in streams running through the region will decrease.
(D) Volume of runoff after rains will decrease.
(E) The frequency of landslides will decrease.

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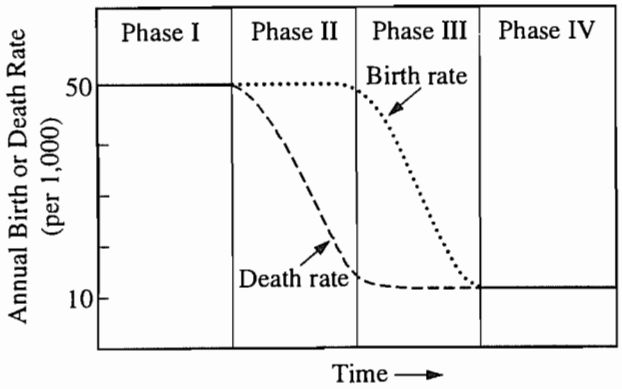
Questions 36-38 refer to the graph below, which shows different phases related to the birth and death rates for a typical human population over time.



36. Zero population growth is associated with

(A) phase I only
(B) phase II only
(C) phase III only
(D) phase IV only
(E) phases I and IV

37. The rate of population growth starts to slow down at which point?

(A) The end of phase I
(B) The middle of phase II
(C) The beginning of phase III
(D) The end of phase III
(E) The middle of phase IV

38. Which of the following is most likely the primary cause of high death rates in phase I ?

(A) Loss of breeding-age males due to warfare
(B) Loss of breeding-age females due to disease
(C) Large percentage of elderly individuals in the population
(D) Infant and childhood mortality
(E) General starvation due to famine

39. Which of the following best shows the process of evolution?

(A) A lizard's color becomes brown as it sits on a log.
(B) A bear goes into hibernation.
(C) A plant loses its leaves in a drought.
(D) A population of mosquitoes develops resistance to a pesticide.
(E) A population of foxes increases as more prey becomes available.

40. Most data indicate that, during the past 100 years, mean global annual temperature has

(A) decreased by 5°C
(B) decreased by 0.5°C
(C) stayed the same
(D) increased by 0.5°C
(E) increased by 5°C

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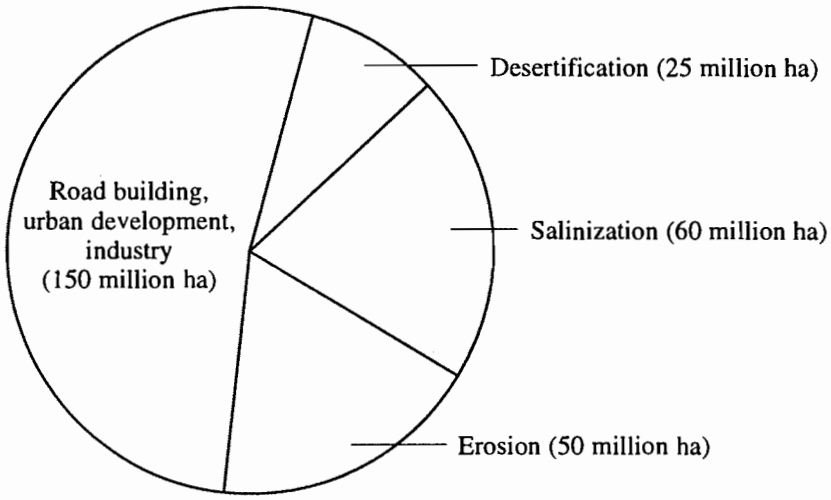
ESTIMATED WORLD ARABLE LAND LOST
BETWEEN 1985 AND 2000



41. According to the information in the graph above, which of the following would most effectively slow the loss of arable land?

(A) Increasing the efficiency of desalination processes
(B) Reducing urban development
(C) Increasing the efficiency of erosion control
(D) Using more extensive irrigation systems
(E) Discovering cheaper energy sources

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42. Environmentalists oppose the mining of antarctic mineral resources because

(A) territorial claims to Antarctica are unresolved
(B) the existence of valuable mineral deposits in the antarctic environment is unlikely
(C) the antarctic environment is fragile and extremely vulnerable to the disturbance that would accompany development
(D) currently known world reserves of important metals and oil are considered inexhaustible
(E) the demand for minerals is expected to decline as the world's nations become more industrialized

43. Fragmenting one large park or preserve into many small parks with human habitation in between them is most likely to lead to which of the following?

(A) Reduction in species diversity
(B) Stabilization of microclimates
(C) Decrease in the proportion of edge habitat
(D) Increase in gene flow within species
(E) Increase in population size of top carnivores

44. Which of the following metals is considered an energy resource?

(A) Uranium
(B) Cobalt
(C) Mercury
(D) Copper
(E) Palladium

45. Of the following, which constitutes the greatest percent of domestic use of water in the United States?

(A) Flushing toilets
(B) Drinking
(C) Cooking
(D) Washing dishes
(E) Washing clothes

46. Which of the following best describes soils in many tropical rain forests?

(A) They lack soil horizons.
(B) They are quickly depleted of nutrients when the forest is removed.
(C) They are similar to soils in grasslands.
(D) They are well suited for growing a wide variety of crops.
(E) They are deep and well drained.

47. Which of the following elements constitutes the highest percentage of mass in Earth's crust?

(A) Oxygen
(B) Aluminum
(C) Carbon
(D) Potassium
(E) Nitrogen

48. If an incandescent lightbulb used for lighting has an efficiency rating of 5 percent, then for every 1.00 joule of electrical energy consumed by the bulb, which of the following is produced?

(A) 1.05 joules of light energy
(B) 1.05 joules of heat energy
(C) 0.95 joule of light energy
(D) 0.05 joule of light energy
(E) 0.05 joule of heat energy

49. The ultimate source of energy for terrestrial ecosystems is

(A) nutrients in soil
(B) nutrients in vegetation
(C) primary consumers
(D) producers
(E) the Sun

50. All of the following gases have been implicated in contributing to the increase in global temperatures via the greenhouse effect EXCEPT

(A) O_2
(B) CH_4
(C) N_2O
(D) CO_2
(E) CFC's

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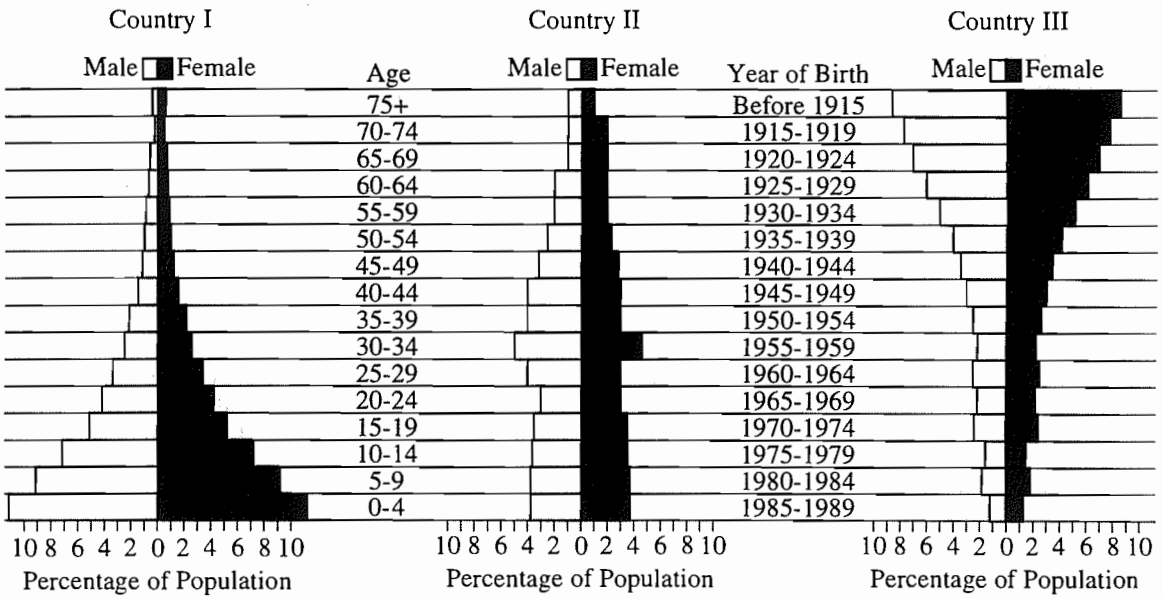
Questions 51-52 refer to the histograms below, which show age structure expressed as percentage of population for Countries I, II, and III in 1990.



51. Countries undergoing rapid population growth include which of the following?

(A) I only
(B) II only
(C) III only
(D) II and III only
(E) I, II, and III

52. Approximately what percent of the population in Country II is under age 15 ?

(A) 1%
(B) 5%
(C) 10%
(D) 25%
(E) 50%

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53. The major reservoirs of nitrogen and sulfur in the biosphere are correctly identified by which of the following?

	Nitrogen	Sulfur
(A)	Rocks	Rocks
(B)	Rocks	Vegetation
(C)	Rocks	Atmosphere
(D)	Atmosphere	Rocks
(E)	Atmosphere	Atmosphere

54. A sample of radioactive waste has a half-life of 10 years and an activity level of 2 curies. After how many years will the activity level of this sample be 0.25 curie?

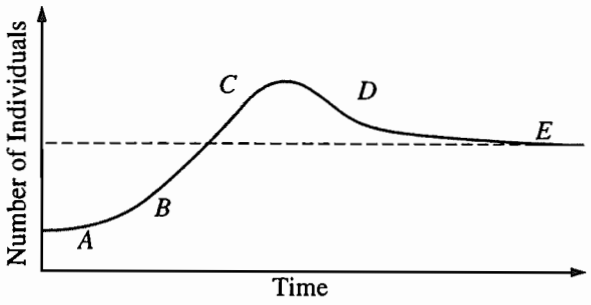
(A) 10 years
(B) 20 years
(C) 30 years
(D) 40 years
(E) 80 years

55. The most abundant gas in Earth's atmosphere is

(A) nitrogen
(B) oxygen
(C) water vapor
(D) carbon dioxide
(E) hydrogen

56. Which of the following would most likely have the greatest positive impact on the quality of the natural environment worldwide?

(A) Discovery of new reserves of fossil fuel in coastal areas
(B) Increased agricultural production on marginal desert lands
(C) Increased life expectancy in more developed nations
(D) Increased reliance on food from ocean ecosystems
(E) Stabilization or reduction of the size of the human population



57. The diagram above illustrates how the number of individuals in a population changed with time as a result of external stresses and resource limitations. Which lettered portion of the curve most likely corresponds to the carrying capacity of the ecosystem?

(A) *A*
(B) *B*
(C) *C*
(D) *D*
(E) *E*

58. Living organisms must acquire energy from their environment. Examples of adaptations that help organisms acquire this energy include which of the following?

I. The dark, heat-absorbing coloration of a reptile.
II. The fangs and claws of a lion
III. The light coloration of a peppered moth

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

59. All of the following substances are derived from petroleum EXCEPT

(A) asphalt
(B) DDT
(C) cellulose
(D) polystyrene
(E) nylon

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60. Most volcanism in the world is associated with

(A) plate boundaries
(B) midcontinental hot spots
(C) faulting
(D) aquifer depletion
(E) desertification

61. Compared with people in developing countries, people in industrialized countries are more likely to eat

(A) beans
(B) beef
(C) corn
(D) rice
(E) wheat

62. The current world population is closest to which of the following?

(A) 1 million
(B) 500 million
(C) 1 billion
(D) 5 billion
(E) 20 billion

63. Which of the following is most likely to result from destruction of wetlands surrounding a river?

(A) A decreased sediment load in the river
(B) A decreased level of pollutants such as nitrates in the river
(C) An increased diversity of aquatic species in the river
(D) An increased level of oxygen in the river
(E) An increased frequency of flooding of the river valley

64. The presence of high levels of fecal coliform bacteria in a water source indicates that the water

(A) is safe to drink
(B) is safe to swim in
(C) contains too little oxygen to support fish life
(D) has been recently chlorinated at a sewage treatment plant
(E) has been contaminated by untreated human or animal waste

65. Of the following, which is the most serious immediate problem associated with sanitary landfills?

(A) Generation of CO_2 gas
(B) Leachate contamination of groundwater
(C) Release of disease organisms
(D) Incomplete degradation of wastes
(E) Compaction and settling

66. Of the following organisms, which occupies the lowest trophic level?

(A) Spider
(B) Deer
(C) Lion
(D) Hawk
(E) Snake

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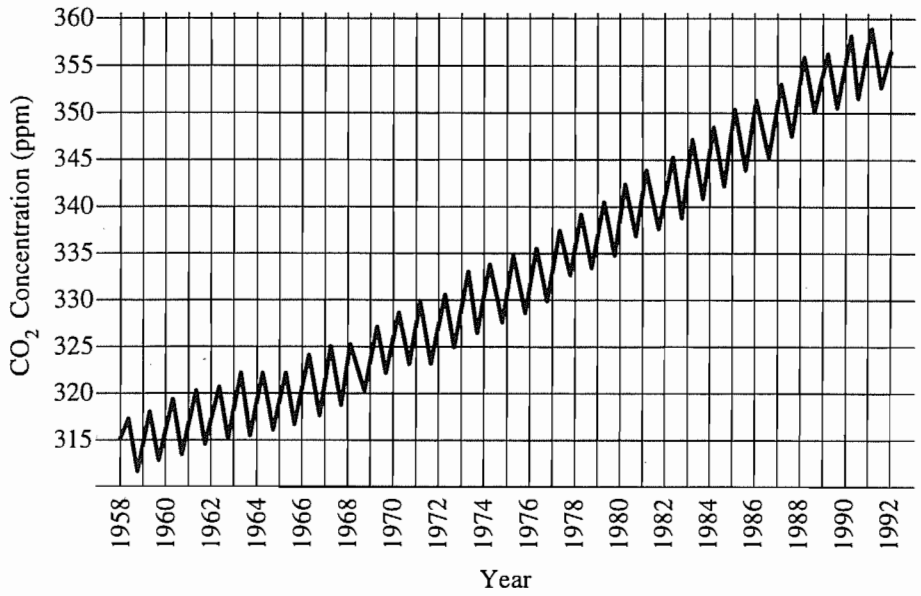
Questions 67-69 refer to the graph below, which shows the monthly average CO_2 concentration, in parts per million, as measured at Mauna Loa Observatory in Hawaii.



67. According to the graph, the increase in CO_2 concentration, in parts per million, between 1970 and 1990 is closest to

(A) 5 ppm
(B) 30 ppm
(C) 50 ppm
(D) 340 ppm
(E) 355 ppm

68. Which of the following is most likely a significant cause of the general trend indicated by the graph?

(A) Reduction of ozone concentrations in the upper atmosphere
(B) Reduction in size of polar ice caps
(C) Increase in energy output of the Sun
(D) Increase in evaporation of ocean water
(E) Increase in consumption of fossil fuels

69. Which of the following most directly explains the periodic fluctuations of the curve?

(A) Daily variations in air temperature
(B) Daily variations in sea level
(C) Seasonal variations in photosynthetic activity
(D) Seasonal variations in ocean water temperature
(E) Seasonal variations in human industrial activity

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70. Which of the following is most likely to be the direct result of lack of genetic diversity in a food crop such as corn?

(A) Decreased kernel size
(B) Decreased potential yield
(C) Decreased dependence on chemical fertilizers
(D) Increased susceptibility to plant disease
(E) Increased resistance to pests

71. Which of the following substances is released by CFC's and catalyzes a chain reaction that breaks down ozone in the upper atmosphere?

(A) Carbon monoxide
(B) Carbon dioxide
(C) Chlorine
(D) Sulfur dioxide
(E) Methane

72. The major biological source of dissolved oxygen in the ocean comes from

(A) decomposition of organic sediments on the ocean floor
(B) metabolic processes of coral in reefs
(C) oxidation of sulfur by bacteria in ocean vent communities
(D) photosynthesis by phytoplankton
(E) respiration by zooplankton

73. Overgrazing of public land by privately owned livestock is an example of the

(A) tragedy of the commons
(B) right of eminent domain
(C) rule of seventy
(D) principle of manifest destiny
(E) swapping of debt for nature

74. In contrast to low-level radioactive waste, most high-level radioactive waste is currently

(A) put into steel drums and dumped into the ocean
(B) incinerated
(C) buried in government landfills
(D) recycled
(E) stored at reactor sites

75. The main environmental effects of ozone depletion could include all of the following EXCEPT

(A) lower food-crop production
(B) decreased concentration of CO_2 in the atmosphere
(C) disruption of marine food chains
(D) increased incidence of skin cancer
(E) reduction of primary productivity in the oceans

76. The primary cause of Earth's seasons is the

(A) constant tilt of Earth's rotational axis with respect to the plane of its orbit around the Sun
(B) changing distance of Earth from the Sun at different times of the year
(C) periodic wobbling of Earth on its axis of rotation
(D) changing relative positions of Earth, its Moon, and the Sun
(E) periodic changes in solar energy output

77. Elements that cycle in the environment and that also have a gaseous phase at some point in their cycle include which of the following?

I. Carbon
II. Phosphorus
III. Sulfur

(A) I only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II, and III

78. There are various stages in the formation of coal as heat and pressure are increased and moisture content is decreased. These stages, in order, are

(A) bituminous, peat, lignite, anthracite
(B) peat, lignite, bituminous, anthracite
(C) peat, lignite, anthracite, bituminous
(D) lignite, bituminous, anthracite, peat
(E) anthracite, bituminous, peat, lignite

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79. Which of the following correctly orders the methods of solid-waste management in terms of energy required?

Least Energy → Most Energy		
(A) Reuse	Recycle	Reduce
(B) Recycle	Reuse	Reduce
(C) Recycle	Reduce	Reuse
(D) Reduce	Reuse	Recycle
(E) Reduce	Recycle	Reuse

80. Although ozone in the stratosphere has been decreasing in recent years, ozone near Earth's surface is on the increase. This ozone near the surface is undesirable because it

(A) absorbs ultraviolet light
(B) has a different chemical structure than stratospheric ozone
(C) reacts with hydrocarbons to form CFC's
(D) is a strong oxidant and a respiratory irritant
(E) accelerates rates of photosynthesis in plants

81. In models of global warming, the most important factor contributing to an increase in sea level is

(A) thermal expansion of the oceans
(B) increased precipitation
(C) decreased evaporation
(D) subsurface ocean cooling
(E) growth of the polar ice caps

82. Which of the following best explains why DDT has been found in penguin eggs in the Antarctic?

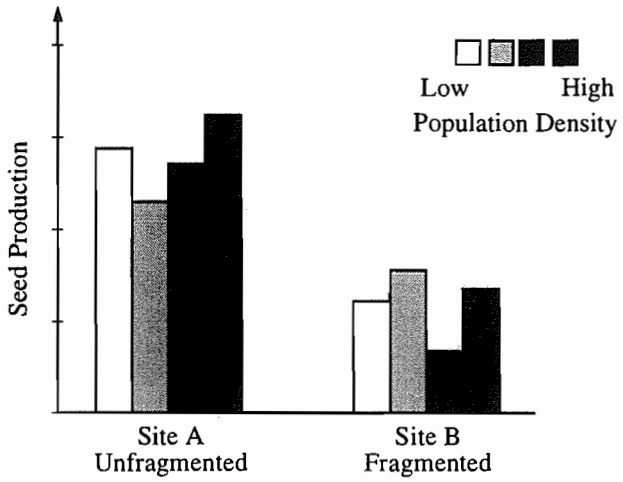
(A) Chemicals used in one region of Earth can circulate in the biosphere and affect organisms in a distant region.
(B) The large number of penguins in Antarctica has resulted in a depletion of their preferred foods.
(C) Although DDT is toxic to adult birds, it has no effect on developing embryos.
(D) Chemicals like DDT are volatile and eventually make their way to the ozone layer.
(E) Because penguins incubate their eggs on land, the eggs are exposed to DDT.

83. Of the following, which is the best example of a point source of water pollution?

(A) Factory effluent
(B) Storm water
(C) Acid precipitation
(D) Agricultural runoff
(E) Residential pesticide runoff

84. Approximately what percentage of the water on Earth is freshwater (liquid and solid)?

(A) 75%
(B) 25%
(C) 2.5%
(D) 0.25%
(E) 0.025%



85. The graph above shows how seed production in a plant species varied with population density in an unfragmented habitat (site A) and in a fragmented habitat (site B). Which of the following conclusions is best supported by the data?

(A) There is no relationship between seed production and habitat fragmentation.
(B) Seed production is higher in dense populations.
(C) Seed production is lower in dense populations.
(D) Habitat fragmentation has more effect on seed production than does population density.
(E) Pollinators are either less abundant or less effective in small populations.

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86. The land on a 100-acre farm is equally suited for grazing cattle and growing corn. Of the following ways of distributing land use, which would produce the greatest number of calories for human consumption?

	Acres for Grazing Cattle	Acres for Growing Corn
(A)	100	0
(B)	80	20
(C)	50	50
(D)	20	80
(E)	0	100

87. Road construction, logging, and mining are banned in which of the following federal lands?

(A) National parks
(B) National wildlife refuges
(C) National forests
(D) National wilderness preservation areas
(E) National resource lands

88. Which of the following best describes the mechanism of the greenhouse effect in Earth's atmosphere?

(A) Ultraviolet radiation from the Sun is absorbed by ozone gas in the stratosphere.
(B) Gamma radiation from the Sun is absorbed at ground level by dust particles in the atmosphere.
(C) Infrared radiation from Earth's surface is absorbed by gases in the atmosphere.
(D) Cosmic radiation from deep space is absorbed by gases in the atmosphere.
(E) Alpha radiation from the Sun is absorbed by water vapor in the atmosphere.

89. In a human population undergoing the demographic transition, which of the following generally decreases first?

(A) Birth rate
(B) Death rate
(C) Average family size
(D) Life expectancy
(E) Level of education

90. Which of the following not only results from greenhouse warming but also contributes to additional warming of Earth (i.e., is a positive feedback process) ?

(A) Increased emissions of particulates and aerosols from industrial activity
(B) Increased volcanic activity
(C) Decreased air temperature and subsequent formation of clouds
(D) Decreased incidence of sunspot activity
(E) Decreased size of snowpack

91. Which of the following is an inorganic compound?

(A) Ethanol
(B) Benzene
(C) Table salt
(D) Sucrose
(E) Propane

92. High rates of species extinction caused by human activities have taken place at which of the following times in Earth's history?

I. At the end of the Permian period
II. At the end of the Cretaceous period
III. During recent times

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

93. The amount of sediment deposited at the mouth of a river system is likely to be increased by the presence upstream of which of the following?

I. Artificial levees and embankments
II. Dams
III. Extensive natural wetlands

(A) I only
(B) II only
(C) III only
(D) I and II
(E) II and III

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94. *El Niño*, a periodic warming of ocean surface waters, occurs in which of the following regions?

(A) Tropical East Pacific
(B) Gulf of Mexico
(C) Arctic North Pacific
(D) Temperate West Atlantic
(E) Tropical Indian Ocean

95. In the removal of a pollutant from wastewater, which of the following is true of the cost per unit of pollutant removed?

(A) It decreases as the toxicity of the pollutant increases.
(B) It decreases as the time passed before remediation increases.
(C) It increases as the concentration of the pollutant decreases.
(D) It increases as the volume of the wastewater decreases.
(E) It does not change over time or with concentration of pollutant.

96. In the United States, the largest single component of municipal solid waste is

(A) glass
(B) paper
(C) food scraps
(D) wood and other construction debris
(E) plastic

97. Which of the following countries has the largest coal reserves?

(A) Saudi Arabia
(B) China
(C) India
(D) France
(E) Japan

98. Which of the following will result in accelerated eutrophication when introduced into streams, lakes, and bays?

(A) Bacteria and viruses
(B) Pesticides
(C) Herbicides
(D) Phosphates
(E) Acid wastes and salts

99. The two major processes involved in the carbon cycle are

(A) weathering and erosion
(B) photosynthesis and respiration
(C) evaporation and transpiration
(D) erosion and deposition
(E) fixation and denitrification

100. Which of the following procedures would be best for remediating the effects of soil salinization?

(A) Application of broad-spectrum biocides to kill microorganisms
(B) Application of superphosphate to increase soil fertility
(C) Addition of clay to increase soil water-holding capacity
(D) Addition of large amounts of water to leach out salts
(E) Addition of lime to raise soil pH

END OF SECTION I

ENVIRONMENTAL SCIENCE
SECTION II
Time —90 minutes
Number of questions—4
Percent of total grade—40

Suggested writing time per question—approximately 22 minutes

Because each question will be weighted equally, you are advised to divide your time equally among them without spending too much time on any one question. You are expected to answer all four questions in this section. Suggested times will not be announced; you may proceed freely from one question to the next.

Each answer should be organized, well balanced, and as comprehensive as time permits. Answers must be in organized, well-written prose form; outline form is NOT acceptable. Do not spend time restating the questions. If a specific number of examples are called for, no credit will be given for additional examples. For instance, if a question calls for two examples, you will receive credit only for the first two examples you provide.

The questions in the green insert are duplicates of those in this booklet. Use the green insert to organize your answers and for scratchwork, but write your answers in the pink booklet. NO CREDIT WILL BE GIVEN FOR ANYTHING WRITTEN IN THE GREEN INSERT.

You are to write your answers with a pen only, preferably in black or dark blue ink. Be sure to write CLEARLY and LEGIBLY. If you make an error, you may save time by crossing it out rather than trying to erase it.

ENVIRONMENTAL SCIENCE

SECTION II

Time—90 minutes

4 Questions

Directions: Answer all four 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 the pink booklet, NOT on the green insert. 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. The environmental impact of washing a load of dirty dishes in an electric dishwasher differs from that of washing them by hand in a sink. Use the information and data below to answer the questions that follow. Show your calculations.

   Assume the following:

   1. The dishes all fit in one load.
   2. The water coming into the water heater for the sink and into the water heater in the dishwasher is at 50°F.
   3. The water heaters for the sink and the dishwasher are both 100 percent efficient.
   4. In one complete cycle, the electric dishwasher uses 10 gallons of water heated to 140°F and the dishwasher also uses 0.500 kilowatt-hour of electrical energy for its mechanical operation.
   5. Washing the dishes by hand requires 20 gallons of water heated to 110°F.

   Other Information:

   1 gallon of water = 8 pounds of water
   1 BTU = the amount of energy needed to raise the temperature of 1 pound of water by 1°F
   1 kilowatt-hour = 3,400 BTU's

   (a) Calculate the total energy (in BTU's) used to both heat the water and run the electric dishwasher to wash a load of dishes.

   (b) Calculate the energy (in BTU's) used to heat the water for washing the load of dishes by hand.

   (c) Discuss the economic and environmental costs and benefits of
      i) using the electric dishwasher (including its manufacture and disposal)
      ii) washing the dishes by hand

GO ON TO THE NEXT PAGE

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2. Refer to the article and diagram below when answering the questions that follow.

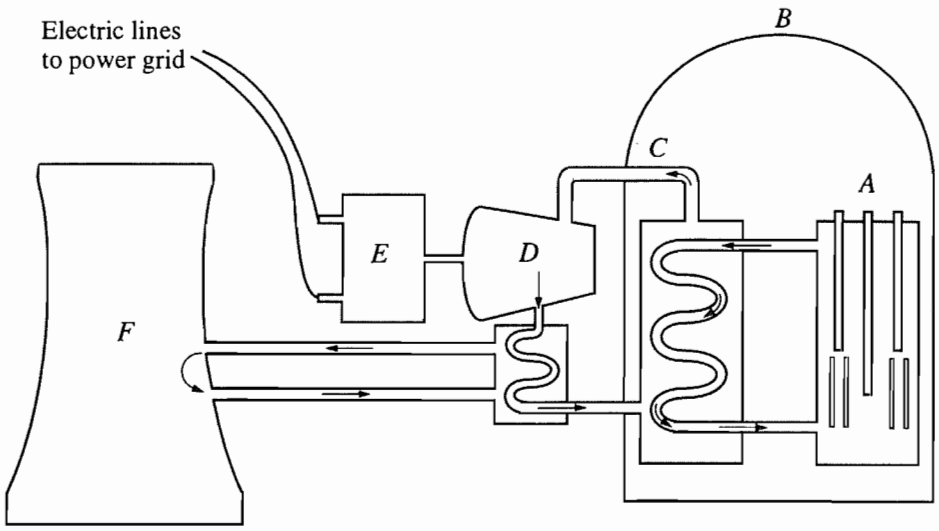
FUTURE OF NUCLEAR POWER IN DOUBT

A long decline for nuclear power in the United States began in the late 1970's when predictions that the price of oil would rise to $100 per barrel did not materialize. In 1979, the near-meltdown at the Three Mile Island nuclear plant in Pennsylvania alarmed the public over the potential hazards of nuclear power. These concerns were further exacerbated by the events at Chernobyl in 1986.

Societal concerns about nuclear power and increased costs associated with the construction and operation of nuclear generating plants have led to a virtual moratorium on new plant construction. In the United States, no new orders for nuclear power plants have been placed since 1979. Even Energy Department officials are now reluctant to predict that another nuclear reactor will ever be built in this country.

Nuclear power plants currently generate 21 percent of United States electricity and the 110 nuclear power plants across the nation are operating more efficiently and safely now than ever before. Some officials believe that if we do not continue research on nuclear energy, then we will not have a viable economy in 30 years.

DIAGRAM OF NUCLEAR POWER PLANT



(a) Identify and describe the function of any three parts labeled on the diagram of a water-cooled nuclear power plant shown above.

(b) Describe and discuss two environmental problems associated with the use of nuclear power for generating electricity.

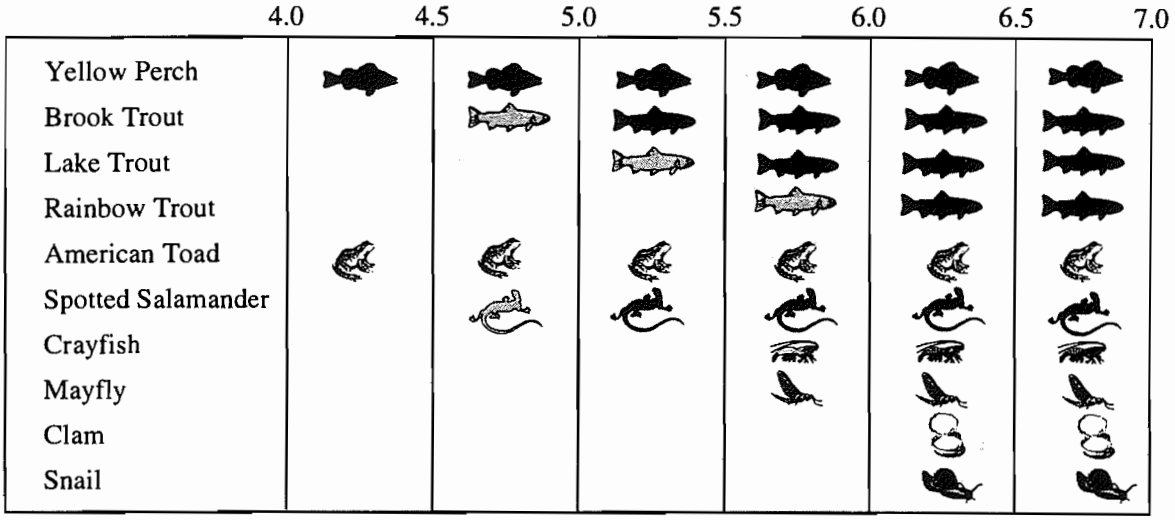
(c) On the basis of the article and other information, what options do you foresee for the future production and use of electricity in the United States?

(d) Describe briefly the environmental implications of your answer in part (c).

GO ON TO THE NEXT PAGE

3. The diagram below represents the pH ranges in which selected aquatic organisms exist. The solid figures represent pH ranges in which the organism thrives. Shaded figures represent pH ranges in which conditions are less favorable, but in which the organism survives. No symbol is placed in a pH range in which that organism cannot survive. Using the diagram and your understanding of environmental principles, answer the following questions.

pH TOLERANCE



(a) Determine the pH range in which brook trout thrive. To what range of hydrogen-ion concentration, [H^+], does this pH range correspond?

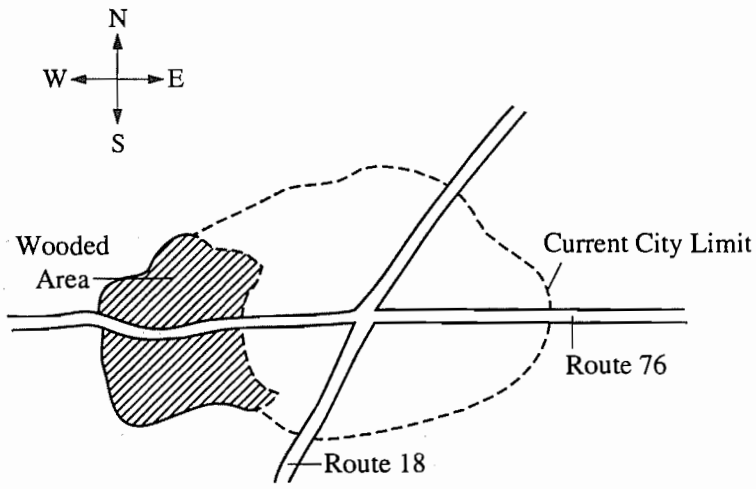
(b) Which organism(s) might best provide an indication that a lake has changed from pH 5.8 to pH 5.2 ? Explain.

(c) Discuss how pH affects biodiversity in a freshwater community. Consider chemical, physiological, and ecological factors in your answer.

(d) Discuss the cause of lake acidification and describe potential ways to avoid or remediate it.

GO ON TO THE NEXT PAGE

4.



Fremont

The map above shows the town of Fremont, where biologists have noted that the population of a certain species of bird has been declining over the past several years. This bird species is now found only in the wooded area on the western edge of the city. Developers view this wooded area as prime real estate and have recommended to the Fremont City Council that the area be zoned for single-family housing. A group of citizens concerned about the bird species and its habitat recommended to the council that future urban expansion be directed toward the eastern portion of the city and that the wooded area be preserved.

(a) Identify and briefly describe two federal laws or regulations that might apply to this situation.

(b) Assume that the Fremont City Council votes to preserve the wooded area. Explain the positive and negative consequences of this action. Include long- and short- term effects on the environmental, economic, and recreational needs of the citizens of Fremont.

(c) Assume that the Fremont City Council votes against preserving the wooded area. Propose and defend an alternative plan that both protects the bird species and provides for urban expansion.

END OF EXAMINATION

AP Environmental Science

1998

APPENDIX - ANSWERS

Matching multiple-choice answers and free-response scoring follow.

Chapter III Answers to the 1998 AP Environmental Science Examination

- Examination Overview
- Section I: Multiple Choice
  - Blank Answer Sheet
- Section II: Free Response
  - Commentary on Free-Response Questions, Scoring Guidelines, Sample Student Responses with Commentary

Examination Overview

The 1998 AP Environmental Science Examination was composed of two parts. Section I consisted of 100 multiple-choice questions worth 60 percent of the final exam grade, and Section II contained four free-response questions worth 40 percent. In order to establish an appropriate grading scale for this new examination, a college comparability study was carried out. In the study, college students completing an introductory environmental science course were given portions of the AP Environmental Science Exam, and their performance on the exam was compared with that of the high school AP students. Many of the AP Environmental Science students scored comparably to the college students receiving As and Bs in their college environmental science courses. Thus, these high school students achieved college-level results and should be eligible for college credit. The percentage of students being recommended for college credit (57.7 percent with an AP grade of 3 or better) was "in the same ballpark" as those taking AP Biology (60.9 percent with an AP grade of 3 or better).

It was reported that the multiple-choice section was finished quickly by many students. This speed in finishing was apparently interpreted by many people as meaning that the multiple-choice section was easy. However, since the scores on the overall test were not extremely high (that is, the percentage of environmental science students being recommended for credit is not very different from biology), it appears that this section of the test was not, in fact, too easy.

The free-response section was perceived by many as harder than the multiple-choice section. Nonetheless, the mean scores were in or near the range that yields the best measurement (i.e., 4 to 6 on a scale of 10). The structure of the questions allowed students to receive partial credit, and the scoring standards allowed students to obtain a full score of 10 in a variety of ways. Importantly though, the standards were designed so that students were not able to score a 10 without getting at least 1 point in each part of the question. The questions were general enough that students could give many different, but appropriate answers; at the same time, the questions were specific enough that students seemed to understand what the questions were asking. Students were graded on their knowledge and reasoning, not on their opinions. For example, two students with widely diverging opinions on whether use of nuclear power should be increased in the U.S. could each receive maximum credit.

Section I: Multiple Choice

Listed below are the correct answers to the multiple-choice questions and the percentage of AP candidates at each AP grade level who answered each question correctly. Following Table 1, a copy of the blank answer sheet appears for reference.

Section I Answer Key and Percent Answering Correctly

Item No.	Correct Answer	Percent Correct by Grade 5	4	3	2	1	Total
1	B	100	99	97	90	77	91
2	A	97	91	94	91	80	87
3	E	98	100	96	90	79	93
4	D	98	99	96	85	77	90
5	B	100	97	93	89	87	93
6	E	92	91	78	70	61	77
7	A	87	81	72	65	61	74
8	D	88	86	82	75	73	80
9	B	97	96	93	91	83	91
10	E	100	94	93	88	69	87
11	C	97	89	81	65	58	78
12	A	93	78	73	54	44	68
13	B	97	95	92	88	70	86
14	A	97	94	83	75	63	80
15	E	90	76	73	51	37	63
16	D	87	73	65	41	19	55
17	D	98	99	98	90	70	90
18	E	100	98	94	88	59	86
19	A	97	86	66	55	47	67
20	D	72	54	38	30	29	41
21	A	100	100	98	98	87	96
22	B	82	76	63	51	35	59
23	D	95	94	77	68	41	74
24	C	85	67	51	46	33	53
25	E	98	89	84	73	51	78
26	B	83	68	44	48	21	50
27	D	55	41	28	26	22	35
28	C	98	99	94	87	72	90
29	B	95	99	96	94	90	95
30	E	98	94	83	80	63	83
31	C	80	79	74	71	58	70
32	E	98	91	95	88	79	87
33	B	100	96	92	87	73	89
34	B	100	99	98	92	81	93
35	A	98	85	87	74	59	79
36	E	93	92	90	87	75	87
37	C	82	77	68	64	63	68
38	D	80	64	53	46	34	52
39	D	100	97	93	89	81	91
40	D	87	66	54	45	34	54
41	B	100	99	94	95	81	92
42	C	100	99	96	84	64	87
43	A	87	79	77	73	61	75
44	A	100	99	94	75	61	85
45	A	68	71	66	70	56	66
46	B	93	76	74	69	53	67
47	A	25	14	9	14	21	15
48	D	78	74	60	47	31	59
49	E	100	97	88	86	71	86
50	A	78	81	65	68	44	66
51	A	100	99	95	94	79	93
52	D	82	75	70	66	49	68
53	D	88	82	74	59	53	69
54	C	85	64	51	32	21	49
55	A	92	84	60	58	39	63
56	E	100	99	96	96	78	93
57	E	90	84	73	68	54	72
58	C	68	52	40	26	24	39
59	C	53	51	40	37	27	40
60	A	93	81	71	50	41	67
61	B	98	93	94	88	87	91
62	D	92	87	83	77	66	81
63	E	95	93	88	80	67	79
64	E	100	96	97	87	76	89
65	B	87	86	80	81	57	73
66	B	67	56	36	24	12	36
67	B	98	94	98	88	74	89
68	E	100	94	79	70	57	80
69	C	78	54	45	38	24	44
70	D	98	88	77	56	38	68
71	C	87	74	53	37	18	50
72	D	95	79	58	52	25	59
73	A	80	80	70	56	42	62
74	E	72	66	62	50	43	55
75	B	92	86	86	71	50	77
76	A	82	68	74	72	59	70
77	D	72	65	50	41	31	48
78	B	78	47	46	35	26	42
79	D	95	90	83	81	58	79
80	D	98	86	69	49	27	62
81	A	82	76	77	57	38	65
82	A	98	96	90	84	54	81
83	A	98	94	82	68	48	74
84	C	77	59	53	47	41	55
85	D	83	80	70	56	36	66
86	E	93	64	40	17	7	42
87	D	53	59	55	57	54	58
88	C	72	51	26	26	23	36
89	B	80	59	43	33	27	44
90	E	58	41	20	14	8	27
91	C	70	53	32	27	35	44
92	C	87	84	79	67	49	71
93	A	37	22	18	14	13	22
94	A	85	71	61	55	44	61
95	C	57	34	31	10	27	29
96	B	83	59	60	56	41	55
97	B	57	31	27	24	18	29
98	D	88	74	52	27	25	54
99	B	90	81	74	70	52	70
100	D	63	41	40	34	31	39

AREA 1 – COMPLETE THIS AREA AT EVERY EXAMINATION.

PLACE AP® NUMBER LABEL HERE.

A. SIGNATURE

To maintain the security of the exam and the validity of my AP grade, I will allow no one other than myself to see the multiple-choice questions and will seal the appropriate section when asked to do so. In addition, I am aware of and agree to the Program's policies and procedures as outlined in the 1998 *AP Bulletin for Students and Parents.*

Sign your name as it will appear on your college applications.

B. YOUR AP NUMBER

C. NAME Omit spaces, hyphens, apostrophes, Jr. or II.

Last Name - first 15 letters | First Name - first 12 letters | MI

D. ADMIN. DAY IN MAY

E. TIME OF DAY

- 6 AM
- 7 AM
- 8 AM
- 9 AM
- 10 AM
- 11 AM
- 12 PM
- 1 PM
- 2 PM
- 3 PM
- 4 PM
- 5 PM

F. AP EXAMINATION TO BE TAKEN USING THIS ANSWER SHEET

Print examination name: _____

Fill in the appropriate oval below for examination name and number.

07	○	U.S. History	55	○	German Language
13	○	Art: History of	57	○	Gov. & Pol.: **U.S.**
14	○	Art: Studio Drawing	58	○	Gov. & Pol.: **Comp.**
15	○	Art: Studio General	59	○	International English Language
20	○	Biology	60	○	Latin: Vergil
25	○	Chemistry	60	○	Latin: Literature
31	○	Computer Science A	66	○	Calculus AB
33	○	Computer Science AB	68	○	Calculus BC
34	○	Economics: **Micro**	75	○	Music Theory
35	○	Economics: **Macro**	78	○	Physics B
36	○	Eng. Language & Comp.	80	○	Physics C: **Mech.**
37	○	Eng. Literature & Comp.	80	○	Physics C: **E & M**
40	○	Environmental Science	85	○	Psychology
43	○	European History	87	○	Spanish Language
48	○	French Language	89	○	Spanish Literature
51	○	French Literature	90	○	Statistics

G. What language do you know best?

- ○ English
- ○ English and another language about the same
- ○ Another language

H. DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

Essay Choices

Fill in the ovals under the numbers of the essay questions you answered in this examination.

1	2	3	4	5	6	7	8	9	10	11	12
○	○	○	○	○	○	○	○	○	○	○	○

SCHOOL USE ONLY

Fee Reduction Granted	Report to Teachers Section Designation
○	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

I.N. 240045 18002 • 00657 • TF18M1300 Q2800-06 CHW97329 1 2 3 4

33

Answer Sheet for May 1998, Form 3UBP

Advanced Placement Program®
THE COLLEGE BOARD

AREA 2 – COMPLETE THIS AREA ONLY ONCE.

I. SEX

- ① Male
- ② Female

J. PRESENT GRADE LEVEL

- ① 9th grade
- ② 10th grade
- ③ 11th grade
- ④ 12th grade
- ⑤ College
- ⑥ Other

K. DATE OF BIRTH

Month	Day	Year
01 ○ Jan.		
02 ○ Feb.		
03 ○ Mar.		
04 ○ Apr.		
05 ○ May		
06 ○ June		
07 ○ July		
08 ○ Aug.		
09 ○ Sept.		
10 ○ Oct.		
11 ○ Nov.		
12 ○ Dec.		

L. SOCIAL SECURITY NUMBER

M. ETHNIC GROUP

- ① American Indian or Alaskan native
- ② Black or African American
- ③ Mexican American or Chicano
- ④ Asian, Asian American, or Pacific Islander
- ⑤ Puerto Rican
- ⑥ South American, Latin American, Central American, or other Hispanic
- ⑦ White
- ⑧ Other

N. EXPECTED DATE OF COLLEGE ENTRANCE

ⓕ	Fall	⑧	1998
ⓦ	Winter/Spring	⑨	1999
ⓢ	Summer	⓪	2000
ⓤ	Undecided	①	2001

O. Will you be applying for Sophomore Standing at college?

○ Yes ○ No

ETS USE ONLY

Exam	Exam
① ②	① ②

P. STUDENT SEARCH SERVICE OF THE COLLEGE BOARD

(Complete ONLY if you are a SOPHOMORE or a JUNIOR.)

○ Yes, I want the College Board to send information about me to colleges, universities, and governmental scholarship programs interested in students like me.

○ No, I do not want the College Board to send information about me to colleges, universities, and governmental scholarship programs through the Student Search Service.

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Q. THIS SECTION IS FOR THE SURVEY QUESTIONS IN THE CANDIDATE PACK. (DO NOT PUT RESPONSES TO EXAM QUESTIONS IN THIS SECTION.) BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL.

1	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	4	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	5	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ						

DO NOT COMPLETE THIS SECTION UNLESS INSTRUCTED TO DO SO.

R. If this answer sheet is for the French Language, French Literature, German Language, Spanish Language, or Spanish Literature Examination, please answer the following questions. (Your responses will not affect your grade.)

1. Have you lived or studied for one month or more in a country where the language of the exam you are now taking is spoken? ◯ Yes ◯ No
2. Do you regularly speak or hear the language at home? ◯ Yes ◯ No

INDICATE YOUR ANSWERS TO THE EXAM QUESTIONS IN THIS SECTION. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION (E). YOUR ANSWER SHEET WILL BE SCORED BY MACHINE. USE ONLY NO. 2 PENCILS TO MARK YOUR ANSWERS ON PAGES 2 AND 3 (ONE RESPONSE PER QUESTION). AFTER YOU HAVE DETERMINED YOUR RESPONSE, BE SURE TO COMPLETELY FILL IN THE OVAL CORRESPONDING TO THE NUMBER OF THE QUESTION YOU ARE ANSWERING. STRAY MARKS AND SMUDGES COULD BE READ AS ANSWERS, SO ERASE CAREFULLY AND COMPLETELY. ANY IMPROPER GRIDDING MAY AFFECT YOUR GRADE.

1	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	26	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	51	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	27	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	52	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	28	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	53	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
4	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	29	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	54	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
5	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	30	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	55	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
6	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	31	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	56	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
7	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	32	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	57	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
8	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	33	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	58	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
9	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	34	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	59	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
10	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	35	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	60	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
11	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	36	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	61	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
12	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	37	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	62	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
13	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	38	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	63	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
14	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	39	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	64	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
15	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	40	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	65	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
16	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	41	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	66	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
17	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	42	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	67	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
18	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	43	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	68	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
19	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	44	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	69	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
20	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	45	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	70	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
21	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	46	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	71	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
22	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	47	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	72	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
23	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	48	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	73	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
24	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	49	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	74	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
25	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	50	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	75	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ

FOR QUESTIONS 76-151, SEE PAGE 3.

DO NOT WRITE IN THIS AREA.

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. IF A QUESTION HAS ONLY FOUR ANSWER OPTIONS, DO NOT MARK OPTION E.

76	A	B	C	D	E	101	A	B	C	D	E	126	A	B	C	D	E
77	A	B	C	D	E	102	A	B	C	D	E	127	A	B	C	D	E
78	A	B	C	D	E	103	A	B	C	D	E	128	A	B	C	D	E
79	A	B	C	D	E	104	A	B	C	D	E	129	A	B	C	D	E
80	A	B	C	D	E	105	A	B	C	D	E	130	A	B	C	D	E
81	A	B	C	D	E	106	A	B	C	D	E	131	A	B	C	D	E
82	A	B	C	D	E	107	A	B	C	D	E	132	A	B	C	D	E
83	A	B	C	D	E	108	A	B	C	D	E	133	A	B	C	D	E
84	A	B	C	D	E	109	A	B	C	D	E	134	A	B	C	D	E
85	A	B	C	D	E	110	A	B	C	D	E	135	A	B	C	D	E
86	A	B	C	D	E	111	A	B	C	D	E	136	A	B	C	D	E
87	A	B	C	D	E	112	A	B	C	D	E	137	A	B	C	D	E
88	A	B	C	D	E	113	A	B	C	D	E	138	A	B	C	D	E
89	A	B	C	D	E	114	A	B	C	D	E	139	A	B	C	D	E
90	A	B	C	D	E	115	A	B	C	D	E	140	A	B	C	D	E
91	A	B	C	D	E	116	A	B	C	D	E	141	A	B	C	D	E
92	A	B	C	D	E	117	A	B	C	D	E	142	A	B	C	D	E
93	A	B	C	D	E	118	A	B	C	D	E	143	A	B	C	D	E
94	A	B	C	D	E	119	A	B	C	D	E	144	A	B	C	D	E
95	A	B	C	D	E	120	A	B	C	D	E	145	A	B	C	D	E
96	A	B	C	D	E	121	A	B	C	D	E	146	A	B	C	D	E
97	A	B	C	D	E	122	A	B	C	D	E	147	A	B	C	D	E
98	A	B	C	D	E	123	A	B	C	D	E	148	A	B	C	D	E
99	A	B	C	D	E	124	A	B	C	D	E	149	A	B	C	D	E
100	A	B	C	D	E	125	A	B	C	D	E	150	A	B	C	D	E
												151	A	B	C	D	E

ETS USE ONLY

	R	W	FS
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PT2			
PT3			
PT4			
TOT			
EQ			
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TA2			

DO NOT WRITE IN THIS AREA.

1. YOUR MAILING ADDRESS

AREA 3 – COMPLETE THIS AREA ONLY ONCE.

- YOUR GRADE REPORT WILL BE MAILED TO THIS ADDRESS IN JULY.
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City

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1	AL	28	NE
2	AK	29	NV
3	AZ	30	NH
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5	CA	32	NM
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8	DE	35	ND
9	DC	36	OH
10	FL	37	OK
11	GA	38	OR
12	HI	39	PA
13	ID	40	RI
14	IL	41	SC
15	IN	42	SD
16	IA	43	TN
17	KS	44	TX
18	KY	45	UT
19	LA	46	VT
20	ME	47	VA
21	MD	48	WA
22	MA	49	WV
23	MI	50	WI
24	MN	51	WY
25	MS	52	Puerto Rico
26	MO		
27	MT	53	Other

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School Code

School Name, City, and State

← Make sure you have correctly entered your School Code and filled in the appropriate ovals.

School Name

City

State

5. COLLEGE TO RECEIVE YOUR AP GRADES

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College Name and Address

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City

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Section II: Free Response

Scoring Guidelines, Commentary on Student Performance for Each Question, and Sample Student Responses

The answers presented here are actual student responses to the four free-response questions on the 1998 AP Environmental Science Examination. The students gave permission to have their work reproduced at the time they took the exam. These responses were read and scored by the table leaders and faculty consultants assigned to each particular question. The actual scores that these students received, as well as a brief explanation of why, are indicated.

For each free-response question, there is first a discussion of students' performance on the particular question based upon the comments of faculty consultants at the Reading followed by the scoring guidelines. Next, three sample student responses are presented, each followed by commentary.

Scoring Guidelines for Free-Response Question 1

Part (a) 4 POINTS MAX (5 points possible)

1) Mass of Water : 10 gal × 8 lb/gal = 80 lbs Water (1)
2) Energy to heat Water: 80 lb × 90°F × 1 BTU/°(F•lb = 7200 BTU (1)
   (ΔT)
3) Energy to run dishwasher: 0.500 KWH × 3400 BTU/KWH = 1700 BTU (1)
4) **Total Energy for Dishwasher** = 7200 BTU + 1700 BTU = 8900 BTU setup (1)
   correct final answer (1)

Part (b) 2 POINTS MAX (3 points possible)

1) Mass of Water : 20 gal × 8 lb/gal = 160 lbs Water (1)
2) **Total Energy for Hand Washing** = 160 lb × 60°F × 1BTU/°F•lb = 9600 BTU setup (1)
   (ΔT) correct final answer (1)

NOTES Parts (a) and (b):

1) If no calculations are shown, no points awarded.
2) If student does not show specific heat (1 BTU/°F•lb), but still gets correct answer — OK
3) If units are not shown — OK
4) Correct setup, incorrect addition or multiplication — OK

Part (c) 4 POINTS MAX (8 points possible)

i) ***Electric Dishwasher*** (internal 2 points max: 1 COST and 1 BENEFIT, either economic or environmental required)

	COST (1)	**BENEFIT** (1)
Econ.	Manufacture — (materials, labor, natural resources)	Uses less energy (cheaper)
		Employs people (sales, production, transport)
		Existence helps drive consumer economy
	Disposal — (transport, fees, etc)	Saves time (must specify how related to economics)
		Parts/Machine can be recycled (jobs, materials)
	Acquisition of dishwasher (expensive)	Water temperature higher (more sanitary)
Env.	Pollution (mining, refining, shipping, etc.) specify type of pollution: air, water, etc.	Uses less energy (conserves fossil fuels)
		Uses less water (treatment costs lower, less impact on aquifers, etc.)
	Solid waste/disposal (landfill, open spaces)	
	Detergents (high phosphates)	

ii) ***Hand Washing*** (internal 2 points max: 1 COST and 1 BENEFIT, either economic or environmental required)

	COST (1)	**BENEFIT** (1)
Econ.	Uses more energy (more expensive)	Employs unskilled/handicapped labor
	More time consuming (labor costs)	Non-acquisition of dishwasher (saves $$)
	Not stimulating high-tech society	
Env.	Uses more water (treatment, aquifers)	Substitutes machine power for human labor
	Uses more energy (more fossil fuels used)	Phosphate-free hand washing detergents
		Longer lifetime (durability, replacement, repair)
		Landfilling requires less space

NOTES Part (c):

1) No credit for questioning assumptions
2) Just listing ideas = NO CREDIT; discussion of cost/benefit required.
   Examples:
   a. listing pollution (water, air, etc) is not enough; must discuss
   b. in part (c) i), less water and (c) ii), more water = 0 pt.
   c. simply stating "time saving" not enough; must relate to economy to get 1 pt.
3) Flippant answer = NO CREDIT; answer must relate to economics or environment
4) If calculations in parts (a) and (b) are reversed (e.g., dishwasher requires more energy than hand washing), but part (c) is interpreted correctly based on these calculations, full credit allowed; no double jeopardy.

Commentary on Free-Response Question 1

Students generally handled this question well; scores for this question were higher than those for all the other questions. They had the most difficulty in doing the calculations [parts (a) and (b)] even though the calculations were simple. Many students seemed well prepared to discuss the economic and environmental costs and benefits of the two methods of washing dishes. Student scores ranged from 0-10, with not too many 0-1 scores and not too many 10s. This question involved demonstration of quantitative skills, i.e., calculations. Many students missed points on the calculations in parts (a) and (b) because they did not show their work. Students need to understand that they may get partial credit for doing the problem even if they don't get the correct final answer. Part (c) involved interpreting the calculations from parts (a) and (b). Many students missed points on part (c) for writing very vague, generalized answers that did not specifically relate to environmental or economic costs/benefits. Many students had the tendency to just restate in words the information derived from the calculations as opposed to discussing the implications of the numbers, which implies that many students demonstrated an inability to draw conclusions from data. Many papers had great essays and received the maximum points for part (c), but received no credit for parts (a) and (b) because no calculations were shown; these students thus received a 4 out of 10.

Some common mistakes and misconceptions:

- Calculations — parts (a) and (b)
  1. Not calculating the change in temperature.
  2. Not understanding unit cancellation/dimensional analysis.
  3. Not showing EVERY calculation.
  4. Not being able to do basic multiplication/addition without a calculator.
- Essay — part (c)
  1. Just listing ideas (dishwasher uses less energy) and not discussing the environmental or economic cost and benefit of this (0 points).
     a. Just saying, "saves energy" for use of the dishwasher. This received 0 points. Students needed to state that less electrical energy means less fossil fuels or nuclear energy used which results in reduced pollution (acid precipitation, thermal pollution, radioactive waste, etc.).
     b. Just saying "saves time" for use of the dishwasher. This received 0 points. Students needed to make the connection between time and money (e.g., not paying minimum wage to hand-washing laborers; enabling women to work outside the home, etc.).
  2. Stating the opposite ideas/concepts for the dishwasher and hand washing (it costs less to run the dishwasher and it costs more to do dishes by hand — 1 point, not 2). Students needed to come up with four different examples to get the full 4 points for part (c) (1 cost, 1 benefit either environmental or economic for dishwashers; 1 cost, 1 benefit either environmental or economic for hand washing).
  3. Stating that there are no manufacturing costs associated with producing sinks. Some students wrote a lengthy, detailed essay on the costs of the dishwasher and the benefits of hand washing but failed to discuss a benefit of dish washing and a cost of hand washing. This type of essay only received 2 out of a possible 4 points.

Sample Student Responses for Free-Response Question 1

Excellent Essay (10 points)

a) 10 gallons × 8lbs / 1 gallon = 80lbs 140°F - 50°F = 90°F 1BTU = 1lb × 1°F

x BTU = 80lbs × 90°F = 7200 BTU + .5 Kw-h

.5Kw-h × 3,400 BTU / 1 Kw-h = 1700 BTU

= 8900 BTU's to run the electric dishwasher and heat the water

b) 20 gallons × 8lbs / 1 gallon = 160lbs 110°F - 50°F = 60°F 1BTU = 1lb × 1°F

x BTU = 160lbs × 60°F = 9600 BTU

= 9600 BTU's to heat the water for hands washing the dishes

c) The economic benefits of using the electric dishwasher is that it saves money by using less energy and time. This means a person does not use as much time as hand washing dishes. However, you have to pay for the dishwasher before you can use. How often you use the dishwasher determines if it actually saves money.

The environmental costs are in the disposal and making the dishwasher. The company probably puts out toxic emissions or harms the environment while making the dishwasher. Then it has to be disposed of if it breaks. Then the dishwasher is thrown in the landfill because there is no way to recycle these materials.

The economic benefits of washing dishes by hand is that you don't have to pay for a dishwasher in the beginning. However, it is going to be more expensive to heat the water and time consuming for hand washing. Handwashing the dishes does not result in throw a broken machine into a landfill, but it still hurts the environment. The water used is then sent to a sewage station where it is treated while only hurting the environment slightly.

Commentary on Essay

Student awarded full point maximum on parts (a) and (b). The addition in step (a) (7200 + 1700) is not clearly shown, but it is implied. Student complies with the question as written by discussing costs and benefits for both the dishwasher (part ci) and for hand washing (part ci).

Good Essay (8 points)

(a) The amount of energy (in BTU's) Required to heat the water and run the electric dishwasher is 8900 BTU's. Work shown:
→ 10 gallons => 80 pds 50° → 140° = 90°
.5 Kwh = 3400/2 = 1700
(89 - 90) + 1700 = 8900 BTU's

(b) The total amount of energy needed to heat the water for hand washing is 9600 BTU
20 gallons → 160 pds 50° → 110° = 60°
160 · 60 = 9600 BTU's

(c) Although the energy required to heat a dishwasher is less, handwashing is still the most desirable option. Handwashing is more efficient in the long-run because the amount of energy required in a dishwashers disposal and manufacturing process is far greater. Since a dishwashers weight and size are so large it is difficult to find appropriate disposal areas for them. Since dishwashers are made up of non-organic materials. The most efficient method of disposal for them is to recycle the parts for re-use, but recycling is extremely energy consuming. The hand-washing the only parts required are the sink and human labor, all of which can be used for other purposes. A dishwasher can only be used for one thing.

Commentary on Essay

Student earns full credit for calculations in parts (a) and (b) but earns only 2 out of 4 points in part (c) by limiting the discussion to dishwasher costs in i) and hand washing benefits in ii).

Fair Essay (6 points)

A. 1) 10 gallons of H_2O = 80 lbs. H_2O Therefore it takes 80 BTU's to raise 80 lbs of water by 1°F.
2) 140°F - 50°F = 90°F, which is the change in temp.
3) 90° x 80 = 7200 BTU's
4) .500 kilowatt hour = 1700 BTU's
5) 1700 BTU's + 7200 BTU's = 8,900 BTU's

B. 1) 20 gallons H_2O = 190 lbs H_2O, therefore it takes 190 BTUs to raise the temp. of 190 lbs of water by 1°F
2) 110° - 50° = 60°, which is change in temp.
3) 60° x 190 = 11,400 BTU's

C. An electric dishwasher is more costly than washing dishes by hand because of manufacturing costs. According to the calculations however, an electric dishwasher is more environmentally friendly because it uses less water and less energy.

Commentary on Essay

Student correctly does all of part (a) earning the maximum 4 points. Student makes careless multiplication error in part (b) (20 x 8 = 190 lbs. of water) but receives maximum 2 points for this part. Part (c) is abbreviated and earns no points. Student refers to "manufacturing" costs (cued by the question) and "less water," but does not discuss in depth or detail.

Scoring Guidelines for Free-Response Question 2

Part (a) (3 points max, must include both ID and FUNCTION; grade first three attempted pairs)
(some leeway allowed for structure indicated, function must be correct for ID)

ID	FUNCTION
A = core, fuel rods, reactor, control rods, moderator	nuclear reaction site, fission
B = containment, reactor building	protective, prevent radiation leakage
C = heat exchanger, steam pipes	heat transfer
D = turbine, turbo-generator	drives generator, kinetic to mechanical E
E = generator, transformer	produces electricity, mechanical to electrical E
F = cooling tower	cools or recycles the H_2O, releases waste heat to atmosphere

Part (b) (4 points max: 2 DESCRIBE + 2 DISCUSS)

(Use of the term 'meltdown' not sufficient for a point, but discussion of environmental effects of meltdown could *receive points)*

DESCRIBE *(must include process)*	DISCUSS *(must include environmental effect)*
meltdown caused by	radiation release effects
loss of coolant	mutations, increase in cancer, death, decrease
fuel rod exposure	population, reduced growth rate, fertility rate, etc.
wastes, used fuel produced	
— storage, disposal, transport	groundwater contamination
thermal pollution generated from cooling	kills acquatic organisms, habitat alteration
leaks, releases radiation to environment	radiation release effects as above
fuel processing, limited fuel	excessive use of resources, habitat destruction
— mining, production, enrichment	specific mining effects
decommissioning	
— storage, disposal, transport	ecological restoration
aesthetics, economics	extraction from unique or remote or fragile area
(must show clear environmental link)	
water use — volume used, intake/output	changes aquatic conditions

Part (c) (2 points maximum)

OPTIONS
+1 for a production method

increase use of alternatives (renewable)
solar, wind, geothermal, hydroelectric, biomass, fuel cells, etc
stay with nuclear fission, breeders
increase, continue use of fossil fuels
develop nuclear fusion

Part (d) (3 points maximum)

IMPLICATIONS
+1 for a production implications (+2 max)

less pollution, cleaner, safer (must be specific)
renewable, effects of dams
long term storage of wastes solved
pollution (specific), nonrenewable
research requires high E input
aesthetics, economics (must show clear environmental link)

Commentary on Free-Response Question 2

Part (a), which required students to identify the names and functions of the parts of a nuclear power plant, was the most difficult part of the question. Students needed to provide both an appropriate name and an accurate description of the function. Students who had not specifically studied nuclear power plants were still able to earn some points by identifying parts common to all types of electrical-generating plants, such as the turbine. Teachers should help students realize that they should not necessarily give up on a question if they haven't studied the topic specifically. Students need to learn to apply the knowledge they have to new situations. With regard to part (c), on future options for energy production and use, it was interesting to see that relatively few students wrote that improved conservation of energy is a possible option. Overall, this question was more difficult than Questions 1 and 4.

In general, students were knowledgeable enough about this topic to earn some points — there were few scores of 0 and 1. This question was broad enough that students had opportunities to earn points in a variety of ways. Most students gained some points in part (b), usually with a description of either radiation release or hazardous waste disposal problems. In part (b), simply naming a problem (e.g., meltdown) was not sufficient to earn a point; a brief description (e.g., meltdown caused by loss of coolant) was necessary for the point. The discussion point (e.g., loss of life, increase in cancer rates among those exposed to radiation) was awarded for information provided specifically about the environmental consequences.

Most students earned at least 1 point in part (c) for choosing an option for the future. They could earn 1 point for choosing an energy production option (solar and continued use of nuclear were the most frequent) and 1 point for choosing an energy use option (conservation, improved efficiency of appliances).

In part (d), students were required to discuss the implication of the option(s) they selected in part (c). No points were awarded for implications not linked to options. Students were required to discuss implications of both their production and use options for full credit in this section. They could receive up to 2 points for discussion of implications of their production option, but for maximum credit, had to receive the third point from discussion of the implications of their use option. As few students provided a use option, most students received only 3 of the 5 possible points available in parts (c) and (d).

Some common mistakes and misconceptions:

Part (a)

- confusion between fission and fusion
- misidentification of power plant parts, e.g., B = the reactor, E = where electricity comes into the plant, F = smoke stack

Part (b)
saying that:

- nuclear power plants release CO_2, NO_x, SO_x, CO, ozone into atmosphere
- radiation is released from cooling tower or with steam
- nuclear energy is very efficient, inexpensive
- meltdown occurred at Chernobyl
- meltdown occurred at Three Mile Island
- Love Canal is a nuclear waste dump

Part (c)

- indicating that *not* using something is a production option for the future

Part (d)

- saying that alternative energy sources (wind, solar) produce no waste or no pollution and are very efficient

Sample Student Responses for Free-Response Question 2

Excellent Essay (10 points)

a) B is the containment building for the entire nuclear reactor. This building, usually constructed of thick concrete, is meant to withstand incredible impact in the case of an explosion resultina from too much increase in heat and pressure caused by the fission process. If an explosion did occurs this building would keep the radiation from entering the atmosphere or surrounding area.

A is the actual reactor and fuel rods. During the fission process, enriched radioactive products such as uranium-235 release electrons and create a constant chain reaction, which creates heat, which in turn is converted to electricity. The fuel rods, when lowered, are able to slow down the amount of reaction of the U-235 atoms.

E is the cooling tower, where the original water from the ~~nuclear reactor~~ second loop experiences lower pressure and condenses and cools. The water is then recycled and sent back ~~to cool the pip~~ to the second loop.

b) One environmental problem associated with nuclear power is thermal pollution. Most often, the water from cooling towers is recycled through a nearby stream. This can signicantly raise water temperatures, therefore reducing the capacity of stream organisms to reproduce effectively. This can seriously lower the biological diversity in the stream. Trout, for example, can only survive in cool waters.

The largest problem of nuclear power is the waste. Although low-level waste such as the products from enrichment is currently stored at government sites, there is a huge controversy over who will take the high-level waste. Following the policy of "Not in my Backyard" numerous States have refused to

bury high-level radioactive waste, some of which run a half life of almost 4 billion years. Problems have been identified as one of the only current storage sites in washington, where groundwater contamination has occured. currently, the government is investigating Yucca Mountain as a storage site, but this has aroused more controversy, since it is on a Native American Reservation.

c.) For the future production of electricity in the United States, I believe there must be more development of solar energy, such as photovoltaic panels, and the use of fuel cells. Hydropower will undoubtedly become more widely used, although this is not the best option environmentally. Since solar power has almost reached its highest efficiency possible, which is 18%, it is time to use this renewable resource.

d.) Unfortunately, solar power does not solve all problems. Storage of electricity is required during night hours and cloudy days, and panels are still relatively expensive. It costs about $13,000 to convert a house to solar. Also, some toxic compounds must be used to create solar cells, although they are harmless compare to the high-level radiation of nuclear power. solar energy, when it works efficiently, is an excellent renewable resource because no energy is wasted. The sun always shines.

Hydroelectric power is also renewable, but it causes many environmental problems. It can dry up parts of rivers or flood them, depending on how much water is let through the dam daily. Dams can also block fish migration routes.

Commentary on Essay

part (a) 3 points (containment, reactor, cooling tower)
part (b) 4 points (1 *describe* point for thermal pollution, 1 *discuss* point for decrease reproductive effectiveness, 1 *describe* point for waste disposal, 1 *discuss* point for groundwater contamination)
part (c) 1 production point for solar
part (d) 2 points (1 point for renewable, 1 point for toxic compounds)

Good Essay (8 points)

a. A is the control rods and fuel rods. This is where the nuclear reaction occurs and where the amount of energy produced is monitored and controlled by rods which can be moved up or down deeper into the fuel rods to intercept neutrons and slow the reaction.
B is the building containing the reactor. Its walls are generally 6 feet thick of cement or other material such that if an accident did occur, it could be somewhat contained. C is the area in which the water is carried it carries hot water through after being heated by the reactor and releases steam, turning a turbine, producing electricity & finally cooled and returned to be heated again. This also controls the reaction somewhat

b. There are many environmental concerns related with the use of nuclear power including waste products and possible meltdown. Nuclear power plants run off of the use of such elements as uranium which is highly radioactive and must be deposited somewhere as a waste product. Many problems arise here in that the half-life of Uranium is thousands of years and there are not many places which are willing to undertake the risk of allowing highly radioactive elements to be deposited there. There is risk of contamination of soil and water and it is difficult to contain the product not to mention the health risks (cancer, etc) associated with contact or close proximity to the element. Also, even though precautions have been taken and safety requirements reenforced, there is no security that meltdown will not occur since in many cases like Chernobyl, it was due to HUMAN ERROR, an unpredictable fault. The problems associated with meltdown are enormous including death of proper plants, wildlife near the area and destruction of all land, soil, and water in the vicinity of it. This is not to mention the harmful effects that could be carried to other places by wind and water and the millions of people and cancer cases that will be caused. A problem like this would take an indeterminable amount of time to clean up.

d. I think I foresee that the U.S. will continue to develop other methods of energy production because nuclear power has too low of a Net energy yield for the negative effects it causes. I think the U.S. will move into using renewable energy sources such as WIND, WATER, BIOMASS, BIOGAS, SOLAR, and other sources such as hydrogen power. This will come about as soon as full-cost pricing begins for electricity. These above stated sources are renewable sources which release less pollutants and have few or no negative effects unlike the nonrenewable sources we must decrease use or use less of including nuclear, oil, and coal. This would decrease the amount of CO_2, sulfur and nitrogen oxides, particulates, radioactive chemicals, smog, health problems & other environmental effects present today as a result of our dependency on nonrenewable, polluting resources

Commentary on Essay

part (a) 2 points (control rods, reactor building)
part (b) 3 points (1 *describe* point for waste storage, 1 *discuss* point for soil/water contamination, 1 *discuss* point for effects of meltdown)
part (c) 1 production point for wind
part (d) 2 points (1 point for renewable, 1 point for decreased air pollutants)

Fair Essay (6 points)

E, is the power grid which recieves electrical energy to send to the other parts of the plant and sends out ~~produced~~ electricity produced by the plant.

Two environmental problems associated with the use of nuclear power for generating electricity include the storage of radioactive material and nuclear meltdown. In the past radioactive materials have been stored in steel drums and put in the ocean, but the drums rust and begin to leak. It is difficult to find places to store this material for the enormous amount of time needed until it would no longer be radioactive. A nuclear meltdown would be devestating to our environment. In long term effects mainly, it would cause birth defects, die-off of animals and plants in surrounding areas, and polluted air with radioactivity.

If the United States would like to remain capable of having electricity, than for one thing we not only need to conserve it, but also our natural resources. This can be done by developing and using such methods of power production as solar power, hydroelectricity, and wind power. If we use these options for future production and use of electricity, I see the United States having electricity for any one who wants it for generations to come. Also if alternative power sources are more widely used than we can eventually phase out fossil fuels and other polluting energy sources. The phase out of these environmentally harmful fuels would mean being able to gradually put a stop to global warming and the Ozone depletion. It would also help cut back on ground level ozone.

Commentary on Essay

part (a) no points
part (b) 3 points (1 *describe* point for waste disposal, 1 *describe* point for radiation release, 1 *discuss* point for birth defects and death from radiation)
part (c) 2 points (1 use point for conservation, 1 production point for solar)
part (d) 1 production implication point for decrease in global warming

Scoring Guidelines for Free-Response Question 3

Part (a) 2 Points Maximum

1 pH range in which brook trout thrive is 5.0 to 7.0.
1 Hydrogen ion concentration is 1×10^{-5} to 1×10^{-7}.

Part (b) 2 Points Maximum

1 internal maximum:

Indicator organisms for pH change from 5.8 to 5.2

1 crayfish
1 mayfly
1 Rainbow trout

1 internal maximum:

Explanation

1 Mayfly: thrives down to pH 5.5; disappears below pH 5.5
1 Crayfish and/or Rainbow Trout: Surviving down to pH 5.5; disappear below pH 5.5

Part (c) 4 Maximum Points

1 internal point maximum:

Within the context of the diagram

1 As pH values decline, the biodiversity decreases
1 As acidity increases, the biodiversity decreases
1 As pH values increase, the biodiversity increases
1 As acidity decreases, the biodiversity increases

3 internal points maximum:

Chemical, physiological, and ecological factors

1 Toxic (heavy, harmful) metals (such as Al, Pb, Cd, Cu, Fe, methyl mercury) are released into solution at lower pH levels
1 Chemical elements (cations) are dissolved and kept in solution at lower pH and leave the lake via outflows
1 Increased nitrogen levels from nitric acid (nitrate salts) stimulate plant growth, resulting in an algal bloom and depletion of other soil nutrients
1 Increased nitrogen levels from nitric acid (nitrate salts) stimulate plant growth, resulting in an algal bloom and a decrease in DO levels to a point out of the range of tolerance
1 Increased death and decomposition result in lower DO levels
1 Reduced photosynthesis (due to plant death) leads to reduced DO levels
1 Reproduction rates (fewer eggs laid, fewer eggs hatched) are reduced
1 Disruption (simplification) of the food web results from the decline or loss of pH-sensitive organisms at various trophic levels
1 Survival of eggs, young, fry or fingerlings is reduced
1 Interferes with respiration, damages gills and prevents oxygen uptake (aluminum overstimulates the production of mucus, suffocating the fish)
1 Causes bone decalcification, interferes with calcium deposition or calcium uptake
1 Disrupts muscle contraction
1 Interferes with enzyme activity
1 Causes tissue (epithelial, epidermal) damage

Part (d) 3 Points Maximum

1 internal point maximum:

Cause of lake acidification

1 Sulfur dioxide in atmosphere reacts with atmospheric gases (oxygen and water vapor) to produce sulfuric acid (acid deposition)

1 NO_x in atmosphere reacts with atmospheric gases (oxygen and water vapor) to produce nitric acid (acid deposition)

1 Sulfuric acid and toxic metals leach from mines

1 Hydrochloric or sulfuric acid industrial wastes are discharged into a watershed (point source pollution)

1 Organic acids (tannic acid, humic acid) enter the lake as a result of the logging process

1 Organic acids and metallic cations in leachate flow into the lake from leaking sanitary landfills

2 internal points maximum:

Potential ways to avoid or remediate (MUST be linked to the cause given in answer above)

Sulfur Dioxide

1 Reduce fossil fuel use

1 Burn lower sulfur fuel

1 Install air pollution device — electrostatic precipitator, scrubbers (flue gas desulfurization)

1 Develop and use alternative (non-fossil fuel) energy sources

1 Burn coal more cleanly and efficiently using fluidized-bed combustion

NO_x

1 Install air pollution device — catalytic converter

1 Reduce use of nitrogen fertilizer because it is a source of NO_x that is vaporized into the atmosphere or released through biological activity

1 Develop and use alternative (non-fossil fuel) energy sources

1 Burn coal more cleanly and efficiently using fluidized-bed combustion

Acidic mining leachate

1 Cover mining spoils

1 Close or cap openings to abandoned mine

1 Collect and chemically treat mining leachate

Acidic industrial waste

1 Stop dumping of acidic industrial wastes into the lake

Landfill leachate

1 Construct/operate sanitary landfills following strict guidelines

1 Install impervious liners (layers of clay, sand, thick plastic)

1 Monitor, collect and chemically treat leachate

Applicable to all

1 Pass laws regarding lower emission levels/fines for non-compliance

1 Add lime (limestone, calcium carbonate, sodium bicarbonate, alkaline substance) to neutralize the acid

1 Add a vegetative buffer zone along edge of the lake to reduce acidic runoff

Commentary on Free-Response Question 3

Students had more difficulty with this question than with Questions 1 and 4. Part of the difficulty involved in answering this question relates to the fact that many students do not understand the logarithmic nature of the pH scale. In general, students could interpret the diagram well. Part (d), on the cause of lake acidification and its avoidance or remediation, was more difficult than part (c). Simply writing "acid rain" was not a sufficient answer for this part of the question; students needed to explain chemical reactions that lead to a drop in pH.

Overall, the students displayed a general knowledge of the concepts addressed in this question. However, many of the students lacked a depth of knowledge as evidenced by their inability to cite specific examples or to explain their answers using appropriate terminology. Some students did not read the question carefully, and consequently, provided a list as an answer rather than a description or discussion as required. Although most students were able to earn one or two points from each section, few students demonstrated the mastery of the concepts that one expects from an AP student.

In part (a), most students were able to read the graphic and state the pH range in which brook trout thrive. However, most students did not know that $pH = -\log [H^+]$, although several understood the 10-fold change in hydrogen ion concentration for each pH unit. Only a few students were able to label the $[H^+]$ as moles per liter.

The majority of the students were able to identify the mayfly, crayfish and/or the rainbow trout as the BEST indicator organisms for the drop in pH from 5.8 to 5.2 and provide an appropriate explanation. Several students gave lake trout as a response, but a clear distinction between thrive and survive (as described) would be more difficult to detect and not as obvious as an organism that is no longer present. Therefore, lake trout is NOT the BEST indicator species.

Some students did not understand the relationship between pH and acidity, that is, they did not know that the lower the pH value, the greater the acidity. Although many students acknowledged that pH does affect biodiversity, not many stated a clear relationship, such as "As pH values decrease, the biodiversity decreases." The subsequent discussions ranged from a superficial restatement of the information in the chart to lengthy discussions of chemical, physiological, and ecological factors. Those that were much too general or vague (such as "alters body chemistry" or "acid kills plants") did not earn points. Some students were verbose without clearly identifying a scientific principle.

Many students took the simplistic approach to part (d), identifying "acid rain" as the cause of lake acidification; others chose simply to list sources. The question clearly asks for a discussion of the cause, which requires a more detailed answer. For the second part of this question, points were earned ONLY for potential ways to avoid or remediate that were linked to the cause that the student cited. Most students earned 1 or 2 points for this section. In general, parts (c) and (d) included many options within the standard to allow for the diversity of approaches and emphases in the teaching of this course.

Some common mistakes and misconceptions:

Part (c)

- A few students confused salinity with acidity and pH.
- Several students stated that a decrease in pH directly caused a decrease in DO.
- A few students were under the impression that acids bioaccumulate or biomagnify.

Part (d)

- Students tended to think that pesticides, herbicides, and fertilizers acidify lakes.
- A few students attributed lake acidity to the use of aerosols.
- Many students identified the addition of lime as a means of remediation, but did not know why and thereby missed the concept of neutralization in their discussion.

Sample Student Responses for Free-Response Question 3

Excellent Essay (10 points)

a) Brook trout seem to thrive when the H^+ ion is $10^{-5} - 10^{-6}$ when the pH is between 5 and 7.

b) Presence of Crayfish may be a good indicator, since they will be present in a lake with pH of 5.8, but will die off before the pH reaches 5.2.

c) Low pH, acid, in a freshwater ecosystem clearly will reduce biodiversity as some species cannot tolerate low pH. Those with greater potential niches will increase to fill their new realized niche, straining the population of species upon which they feed.

Shell fish will in particular be harmed, and any vertebrates, because calcium will become more quickly lacked, as it does in acidic water. With less calcium in the soil + water, plants will have less calcium, and this lack of calcium will be more marked in consumers (especially high-order), which will have thin shells and weak bones, making them vulnerable to predators, and making their eggs (if these eggs have shells, as water fowl's do) unlikely to survive to maturity.

D) Lake acidification is the result of acid deposition (both wet and dry, though more significantly wet). Acid rain + snow, when they fall into the lake, make the water more acidic. Acid deposition is itself the result of air pollution, specifically the emission of sulfer oxides, which react with atmospheric gases and water, to form H_2SO_4, sulfuric acid. This acid falls from these acidic clouds as acid rain ($SO_3 + H_2O = H_2SO_4$) and snow. Acid deposition can be prevented by reduction in the amount of air pollution released, especially that which contains sulfer. Coal, for example, in the bituminous state, often contains sulfur deposits, and when it is combusted, H_2SO_4 is the end result. If then, non-combusting sources of energy were adopted, and/or non-combusting cars (which also release some sulfer and much nitrate, which becomes nitric acid), acid deposition would be reduced.

Lake acidification can be partially remedied by the addition of lime into the lake, which acts as a neutralizing agent, but avoidance is a more effective and less expensive proposition.

Commentary on Essay

part (a)	1 point	for pH between 5 and 7, 1 point for H^+ concentration = 10^{-5} to 10^{-7}
part (b)	1 point	for crayfish as indicator, 1 point for explanation: crayfish present at pH 5.8, but die off before pH reaches 5.2
part (c)	1 point	for low pH clearly will reduce biodiversity
	1 point	for calcium leached in the soil and water
	1 point	for eggs unlikely to survive to maturity
part (d)	1 point	for sulfur oxides react with atmospheric gases and water, to form H_2SO_4
	1 point	for adopting non-combusting sources of energy
	1 point	for addition of lime into the lake, which acts as a neutralizing agent

Good Essay (8 points)

a.) The brook trout thrives in the 5.0 to 7.0 pH range.
$[H^+] = 1.0 \times 10^{-5}$ to 1.0×10^{-7}

b.) The organism that might best provide an indication that a lake has changed from pH 5.8 to pH 5.2 are the mayfly and the crayfish. Both of these organisms can survive in the pH water with a pH of 5.5 and above. However, in an environment with a lower pH (more acidic), both organisms cannot survive. Thus, the disappearance of these organism will indicate the decrease of the pH level.

c.) The most favorable aquatic environments have neutral pH levels. The more acidic the water becomes, the less the organisms there are, the less biodiversity.

From the pH Tolerance chart, it is evident that most organisms thrived between pH 6.0 and pH 7.0. As the pH decreases, the number of organisms that thrive decreases. The increase in acidity of the water affects the fish's ability to survive. This is why acid rain has such adverse effects in marine ecosystems. The smaller organisms, such as the snail, clam, mayfly and crayfish, have lower tolerance while the amphibians are more tolerant of the pH level decrease. The different types of fish have different levels of tolerance. The primary consumers are affected mostly by the decrease in pH level because phytoplankton are sensitive to the pH change.

d.) Lake acidification is caused by acid deposition. The sulfur oxides released in the atmosphere by the combustion of fossil fuels and volcanic activity react with water vapor in the atmosphere forming sulfuric acid and other salts. These are precipitated back to earth as acid deposition. To remediate acid it, there must be a reduction of fossil fuel combustion and an increased reliance on renewable energy resources. Emphasis should be placed on renewable resources. Also, the by-products of coal combustion can be filtered to make it safer to the environment when released. Some have "scrubbers" in the smokestacks to clean out some of the sulfur. Coal is also cleaned, taking away some of its sulfur content.

Commentary on Essay

part (a)	1 point	for pH 5.0-7.0, 1 pt. for $[H^+] = 1.0 \times 10^{-5}$ to 1.0×10^{-7}
part (b)	1 point	for mayfly (or crayfish), 1 point for explanation: mayfly/crayfish present when pH is above 5.5, absent at pH below 5.5
part (c)	1 point	for as the pH decreases, the number of organisms that thrive decreases
part (d)	1 point	for SO_x released in the atmosphere by combustion of fossil fuels, reacting with water vapor forming sulfuric acid
	1 point	for reduction of fossil fuel combustion
	1 point	for increased reliance on renewable energy resources or for scrubbers: student already earned maximum points for part (d)

Fair Essay (4 points)

(a) The brook trout thrives in water of pH 4.5 - 5. This water would be very acidic which would be a high concentration of hydrogen ions

(b) To detect a pH change of 5.8 - 6.2 one would look at the health of the Crayfish. It is shown on the graph that Crayfish thrive better in acidic water compared to more neutral waters.

(c) The pH of a body of water determines what kind of life ~~can~~ that can live in it. If an organism adapts to acidic or water that has high alkalinity it can live only in that form of water. A freshwater community would have a species diversity of only those accustomed to the pH of the water. Some organisms have special bodily functions for different waters. They population varies in different waters which would cause adaptations in the organisms.

(d) There are many factors for acidification of a lake. Industries burning fossil fuels will emmit sulfer byproducts such as Sulfur dioxide. Sulfur dioxide will mix with water which forms sulfuric acid or acid rain. This acid rain can travel many miles and deposit in a lake miles away from the industry. Acid rain is a nonpoint pollutant. Regulations on industrial emissions can be placed on industries. Scrubbers can be placed on industrial smoke stacks and car emissions. A catalytic converter is used on every car in Los Angeles to lower sulfur and other pollutants from ~~cars~~ the burning of fossil fuels. Alternatives to fossil fuels can be used or developed to lower emissions.

Commentary on Essay

part (a) 0 points
part (b) 1 point for crayfish
part (c) 0 points
part (d) production implication point for decrease in global warming
1 point for regulations on industrial emissions
1 point for scrubbers

Scoring Guidelines for Free-Response Question 4

Part (a) Maximum 3 points

As this question is presented, no specific federal regulation would prevent the development of the wooded area on the west side of Fremont. However, the question as stated, allows the student to develop a scenario in which one or more of several federal acts or regulations "might" apply. In order to get points for this part of the question, the student must indicate the act, link it to the situation in Fremont and explain/describe the regulatory function of the act.

2 points **Endangered Species Act**

1 One point for naming; only in the case of the ESA can a student receive a point for just writing the name of the law without any further written explanation. Students may indicate this law applies only if this species is endangered or threatened.

1 Alternatively, students may explain that the ESA requires protection for any species that may be endangered or threatened and that this protection takes precedence over economic concerns. (1 point for connecting the bird to the law or for explaining the law.)

OR

2 points **For each piece of legislation below a student can earn up to 2 points.**

1 One point is awarded if the student names the piece of legislation and relates it to the Fremont situation.

1 **A second point** is awarded if the student provides a good description or understanding of the law. This second point may be awarded even if the student has not specifically named the law.

Clean Water Act — If the wooded area were legally classified as a wetland then this federal legislation would apply (Section 401). This act would then prevent the city from developing this tract of land. The law says that there may be no net loss of wetlands.

Safe Drinking Water Act — If the wooded area helps to provide water to the Fremont water supply or aquifer, then the wooded area may be serving as a watershed and might be protected by the law.

Migratory Bird Treaty Act — If the bird species is migratory between the U.S. and Canada its habitat may be protected by this act. This act prevents the destruction of the habitat of non-game migratory bird species.

5th Amendment to the U.S. Constitution (Taking Clause) — If the land under consideration is privately owned and as a result of any level of preservation is rendered worthless to its owners, the 5th amendment may protect the owners' right to develop.

National Environmental Policy Act — If the development involves any federal land or funding, then NEPA may apply and be used to protect the woods. NEPA instructs the federal government to take the environment into consideration when federal projects are undertaken. It also mandates that an Environmental Impact Statement be conducted whenever a major federal or federally funded project involves possible environmental impacts.

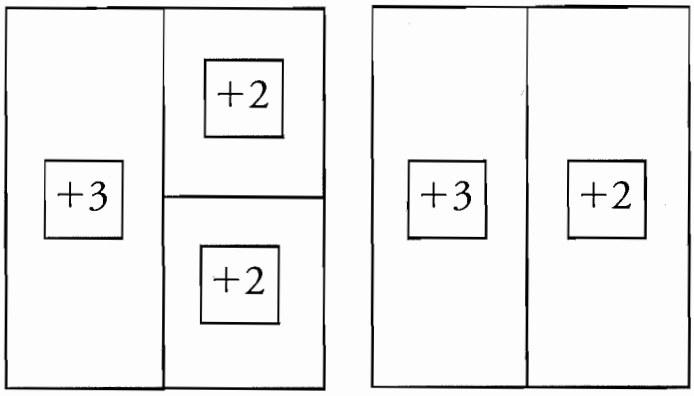
Wilderness Act — If the land tract is designated as wilderness or is being considered for such status, then the Wilderness Act may apply and could be used to protect the woods. The Act says that any land designated as wilderness is to remain roadless and free of development.

Clean Air Act — If the development increases air pollution to the point where it exceeds federally mandated levels, the Clean Air Act may apply and may be used to prevent further development.

Part (b) Maximum 6 points

3 points Three points possible from positive consequences, 2 points possible from short-term negative consequences, 2 points possible from long-term negative consequences; in the case that the student does not differentiate between short- and long-term negative consequences, then only 2 points are possible for negative consequences, thus creating a situation in which only 5 points are available for this part of the question.

Internal Maximum Grading Matrix



Use when short- and long-term negatives are included

No differentiation between short- and long-term

3 points possible **Positive Consequences**

- ☐ preservation of the bird species and/or its role in the ecosystem
- ☐ preservation of biodiversity
- ☐ availability of outdoor recreational activities such as hiking, photography, hunting, bird-watching, etc.
- ☐ tourism or ecotourism
- ☐ may be used as an educational resource
- ☐ preservation of water quality
- ☐ prevention of soil erosion
- ☐ helps to maintain air quality standards
- ☐ provides aesthetic amenities
- ☐ provides for habitat preservation
- ☐ helps to maintain the microclimate of the surrounding area

2 points possible **Negative Short-Term Consequences**

- ☐ loss of construction-related jobs
- ☐ loss of real estate sales revenues
- ☐ loss of construction-related revenues to the local economy
- ☐ loss of revenues to materials suppliers (lumber, concrete, and brick companies, etc.)
- ☐ may redirect public attention away from the need to further protect the bird
- ☐ loss of tree sale revenues

2 points possible **Negative Long-Term Consequences**

- ☐ loss of property tax revenues
- ☐ possible loss of local and sales tax revenues
- ☐ diminished housing availability, which could create overcrowding elsewhere
- ☐ loss of revenues and reduction of commerce in the local economy
- ☐ loss of anthropogenically created forms of recreation such as tennis, basketball, skating, etc.
- ☐ increase in the cost of homes due to a limited supply of houses

Part (c) Maximum 6 points

Students will present a wide variety of plans for the wooded area (**1 point**), sometimes with a brief explanation (**1 point**), and occasionally with an extensive elaboration (**1 point**). Credit is given for only one plan and its explanation. An elaboration should defend the proposed plan and may include elements of more than one plan.

Pictures and drawings may support written text, but cannot receive points unless accompanied by written text. In the event that a student were to suggest development somewhere else other than the wooded area, **only 2 points** would be possible for part (c): **1 point** for a plan and its brief explanation and **1 point** for an elaboration of the plan.

Possible Plans/Scenarios (students will receive credit for only one plan)

- **Partial Development Plan** (students may use a different label; one of the following is likely to provide a sufficient plan)
  - ☐ cluster housing development (putting groups of houses together)
  - ☐ higher density housing (use of common walls, etc.)
  - ☐ use of multi-storied housing instead of wide-spread single-storied housing
  - ☐ preserve most sensitive area; develop least sensitive area
  - ☐ full development of only one-half or other fraction of the total property
  - ☐ peripheral development (perimeter of wooded area)
  - ☐ center development of area with a greenbelt
  - ☐ a scientific investigation into the viability of the species which will then help to direct development
- **Regulated Development** (students may use a different label; in most cases several of the following policies are needed in order to protect the bird)
  - ☐ ordinance requiring tree preservation
  - ☐ ordinance banning walls, fences, lawns, golf courses, large suburban-style parks (this will protect habitat and reduce anthropogenic interference)
  - ☐ lot size regulations to prevent subdividing
  - ☐ codes to encourage preservation and creation of nesting sites
  - ☐ underground placement of utilities and installation of unobtrusive lighting
  - ☐ noise regulations
- **Full Development with Species Relocation or Habitat Purchase**
  - ☐ any plan in which members of the bird species are relocated to a different but similar location (this could include a captive breeding program designed to increase the bird population) which would allow for full development of the parcel without restrictions (students may indicate that this is risky because there is no assurance that the species will survive in a new location)
  - ☐ students may suggest that habitat could be purchased elsewhere (outside of the wooded area in an effort to protect and preserve members of the same bird species

Commentary on Free-Response Question 4

Question 4 required students to integrate concepts learned in different units at different times and in different contexts throughout the course and apply them to a complex, "real world" situation. The ability to understand the interrelationships of different concepts and their application to the solution of complex environmental problems is essential in environmental science and is likely to be assessed in future AP Environmental Science Exams.

In general, students were able to earn some points on this question. There were very few blanks or zeros, and only a few 1s and 2s. Most students who earned low scores — 2 to 4 — did not correctly identify any federal regulations that might have applied to this situation, and received all of their points in parts (b) and (c). Students had the most difficulty with part (a) and the least difficulty with part (c); overall, this question was easier than Questions 2 and 3.

Part (a) of question 4 was most often missed by students because they did not identify a federal act or regulation that "might" apply to the Fremont situation. Because the question led students naturally to the Endangered Species Act, this law was the only one for which a name only was deemed acceptable. In other cases, students needed to give the name of the law and state under which conditions it would apply. For example, the Wilderness Act would apply if the area were part of a declared wilderness area. Many students could not indicate a single correct federal act that might be applicable under a specified set of conditions. In many cases students could identify one or more acts, but couldn't link those acts to the situation by indicating the conditions that would have to exist in order for them to be relevant.

Part (b) was the major part of question 4, being worth a maximum of 6 points. Most students got at least a few points on this part of the question. The biggest problem students had with part (b) was in indicating the specificity of the effect. Students often made only general statements such as "negatively affects the economy," or "improves the environment," or "enhances the recreational opportunities for the citizens of Fremont" rather than noting specific effects such as "the economy will be impacted negatively as a result of lost construction jobs, decreased tax base, decreased sales of homes, etc.," or "the recreational opportunities of the citizens will be enhanced by having hiking trails and through bird watching, etc."

In part (b), many students had difficulty organizing their answers and clearly distinguishing positive and negative consequences, long and short term effects, and economic and environmental and recreational needs. For part (c), students earned, in most cases, 1 point or 2 points for a plan and a brief description of their plan; however few presented sound, ecologically-based plans and defended those plans, clearly indicating how they would address the negative consequences indicated in part (b).

Some common mistakes and misconceptions:

Part (a)

- Failure to identify an act or regulation that reasonably might apply
- Failure to identify a piece of legislation that has been designed to regulate development
- Failure to link a correct act or regulation to the situation described for Fremont

Part (b)

- Failure to categorize the consequences as to whether or not they are negative and positive
- Failure to identify a specific effect
- Failure to balance the positive and negative consequences

Part (c)

- Failure to base plan on sound ecological principles
- Failure to explain how plan will address the effects described in part b
- Failure to defend the plan as required by the question
- Failure to propose a plan that results in development within the wooded area as required by the question

Sample Student Responses for Free-Response Question 4

Excellent Essay (10 points)

The Endangered Species Act and ~~the~~ Preservation laws are both on the side of the concerned citizens. ~~On~~ On a parallel situation, the Northwest was able to save its spotted owl population because it was an endangered species. Land was preserved and made into a wildlife reservation for the creatures. The same could be done in the Fremont scenario.

If Fremont votes to keep the wooded area it would be a beneficial step. The natural area would create a cleaner city that may diffuse smog or other pollutants by creating oxygen.

Short term it would keep a bird population alive and perhaps long ~~term~~ term too. Economically it makes the ~~city~~ city a more desirable place to live, creating a higher standard of life. If it were made into a preserve ~~or~~ or ~~park~~ park it could generate tourism profits and would create a recreational and educational haven for Fremont citizens.

In light of everything, the negatives include less taxable land for the local government, and the loss of a single family housing development on the local route - though another could be built. Beauty is only a value to some.

Should the Fremont City Council vote against preserving the woods, a neighborhood with environment in mind could be created. Using only part of the land the city ~~could~~ could ecologically mindedly build roads and ~~sewers~~ sewers. The Audubon society could be contacted to ensure the count and

habitat of the birds regularly. The city could ensure that trees and plants necessary for survival were maintained and the city could educate citizens about the environment and sustaining the habitat. It would be a cooperational venture to ensure the safety of the birds and the surrounding ecosystem.

Commentary on Essay

part (a)	2 points	ESA and linkage to the act. Student clearly indicates how the act "might" be applicable.
part (b)	5 points	Student maxed on "positive": preservation of bird, specific outdoor recreational activities and tourism, and improved air quality.
	2 points	Two points for "negative" effects: loss of tax revenue and loss of "single family housing."
part (c)	3 points	3 points for part c. Plan (ecologically planned development), description of plan, and a defense/elaboration (careful monitoring and education).

Good Essay (8 points)

Two federal laws that might apply would be the Endangered Species Act which might protect the birds by labeling them threatened. Another might be eminent domain which would allow whoever owns the land, because it is privately owned to do whatever he wants with it (like developing it or protecting it).

If the Fremont City Council votes to preserve the area there would be both positive and negative effects. Positively, the wooded area could remain as a habitat for many wildlife species, the # of birds would most likely increase, urbanization would decrease which is environmentally beneficial, the building of roads would decrease which leads to less runoff, the wooded area can provide outdoor recreation, wooded areas help prevent pollution through absorption and recharging the air, trees help recharge the water supply and provide a buffer to prevent the water supply from being polluted; the birds help control insect populations that might not otherwise be controlled. In addition, use of the park as a outdoor recreational area might increase in the revenue for the town; thus, being economically beneficial. Another positive aspect is leaving the area as a wilderness area decreases population of the town. Less population usually means less pollution and less crime in general.

Negative consequences of this action include; less people moving into town equals less business and less economic growth. Also this smaller amount of revenue from population growth means that there is less money for other things such as education. The birds might continue to decline despite protecting the area and thus the towns efforts would have been in vain.

An alternate plan might be to zone part of the area as single-family housing, but instigate stricter laws for the people who live there which would help protect the birds. This would both protect the birds and provide for economic growth. Perhaps the development could be on 1 side of the highway because Route 76 already fragments the birds habitat so it might not make that much of a difference

Commentary on Essay

part (a)	2 points	Student earns a point for ESA, and a point for indicating this "might" apply if the bird is threatened.
part (b)	3 points	The student earns a maximum of 3 points for benefits: preservation of biodiversity, outdoor recreation, and improvement of air and water quality, and one point for the negative impact of business and economic loss.
part (c)	2 points	In this part of the question, the student's plan and description, while weak, are acceptable and worth 2 points.

Fair Essay (6 points)

The Endangered Species and Wildlife Preservation Law and are two laws that might apply to the Fremont situation. The birds are to be protected under the Endangered Species and Wildlife Preservation Law. Since the species of bird has been on a decline and has found a home where it is surviving, they should not be able to be harmed. The trees should not be cleared since there is an area already cleared. The area is around the same size and will serve the same purpose, just without harming the birds. If the Fremont City Council votes to preserve the wooded area there will be positive and negative consequences of this action. The birds will have a chance to survive in the wooded area if the land is preserved; that is a positive aspect. Some people will be upset that the land has been kept from being zoned because of a species of birds. They will be upset if the birds die off, but then they have another chance to build again. Thats one negative consequence of saving the woods and the birds. If the building cannot be built across town, the town may loose money from the profits a single-family housing complex would provide. People may also move out of town if the birds are saved or not, since some people are pro-environment and con-environment. This will cause a loss in the towns finances. If the Fremont City Council votes against preserving the wooded area and alternative plan would be needed to protect the bird species and provide urban expansion. If half of the trees were to be removed and the complex built on half the area and the other half of the complex be built a little further east, some of the birds would be saved. For the trees which are removed, trees must be replaced around town and the birds must be taken out of the land which will be built upon and put in the new trees around town. This way the birds have a chance to grow around the whole town of Fremont and the single-family homes can still be built. This plan will give the citizens who are concerned about the bird species what they want and the developers and builders will be able to construct the homes in the desired area.

Commentary

part (a)	1 point	One "weak" point for "Endangered Species Law."
part (b)	1 point	One point for saving the bird. No other correct positive benefit mentioned.
	2 points	Student received maximum of 2 points for negative effects: profit from new home, and loss of town revenues resulting from population decline.
part (c)	2 points	1 + 1 for plan and a good description of plan.

Chapter IV Statistical Information

- Table 4.1 — Section II Scores
- How AP Grades Are Determined
- Table 4.3 — Grade Distributions
- Table 4.4 — Section I Scores and AP Grades
- College Comparability Studies
- Reminders for All Grade Report Recipients
- Reporting AP Grades
- Purpose of AP Grades

Table 4.1 — Section II Scores

These are the score distributions for the total group of candidates on each free-response question from the 1998 exam.

	Data-Set Question		Document-Based Question		Synthesis & Evaluation		Synthesis & Evaluation	
Score	Number of Students	% At Score	Number of Students	% At Score	Number of Students	% At Score	Number of Students	% At Score
10	274	5.3	64	1.2	19	0.4	33	0.6
9	541	10.5	125	2.4	45	0.9	140	2.7
8	836	16.3	257	5.0	150	2.9	349	6.8
7	676	13.1	412	8.0	307	6.0	659	12.8
6	478	9.3	533	10.4	521	10.1	838	16.3
5	357	6.9	670	13.0	883	17.2	1012	19.7
4	421	8.2	712	13.8	1071	20.8	784	15.2
3	417	8.1	713	13.9	958	18.6	577	11.2
2	424	8.2	704	13.7	611	11.9	318	6.2
1	348	6.8	531	10.3	326	6.3	131	2.5
0	231	4.5	183	3.6	129	2.5	78	1.5
*NR	140	2.7	239	4.6	123	2.4	224	4.4
Total Candidates	5143		5143		5143		5143	
Mean	5.41		3.92		3.93		4.81	
Standard Deviation	2.99		2.46		1.99		2.21	
Mean as % of Maximum Score	54		39		39		48	

*NR — No response. Student gave either no response or a response not on the topic.

How AP Grades Are Determined

Students could have received 0 to 100 points in Section I and 0 to 40 points in Section II of this exam. However, these scores are not released to the student, school, or college. Instead, these raw scores are converted to grades on an AP 5-point scale, and it is these grades that are reported. This conversion involves a number of steps, which are detailed on the Scoring Worksheet on the facing page:

1. **The multiple-choice score is calculated.** To adjust for random guessing, a fraction of the number of wrong answers is subtracted from the number of right answers. This fraction is 1/4 for five-choice questions (as on the Environmental Science exam), so that the expected score from random guessing will be zero.

2. The free-response score is calculated. When the free-response section includes two or more parts, those parts are weighted according to the value assigned to them by the Development Committee. This allows the Committee to place more importance on certain skills to correspond to their emphasis in the corresponding college curriculum.

3. **A composite score is calculated.** Weighting also comes into play when looking at the multiple-choice section in comparison to the free-response section. In consultation with experts from the College Board and ETS, the Development Committee decided that Section I should contribute 60% to the total score and Section II should contribute 40% to the total score. The maximum composite score was 150, with Section I contributing up to 90 points and Section II contributing up to 60 points. The Scoring Worksheet details the process of converting section scores to composite scores for this exam.

4. **AP grades are calculated.** The Chief Faculty Consultant sets the four cut points that divide the composite scores into groups. A variety of information is available to help the CFC determine the score ranges into which the exam grades should fall:

   - Distributions of scores on each portion of the multiple-choice and free-response sections of the exam, along with totals for each section and the composite score total, are provided.
   - With these tables and special statistical tables presenting grade distributions from previous years, the CFC can compare the exam at hand to results of other years.
   - For each composite score, a roster summarizes student performance on all sections of the exam.
   - Finally, on the basis of professional judgment regarding the quality of performance represented by the achieved scores, the CFC determines the candidates' final AP grades.

See Table 4.3 for the 1998 AP Environmental Science Exam grade distributions.

If you're interested in more detailed information about this process, please see the "Technical Corner" of our website: www.collegeboard.org/ap. There you'll also find information about how the AP Exams are developed, how validity and reliability studies are conducted, and other nuts-and-bolts data on all AP subjects.