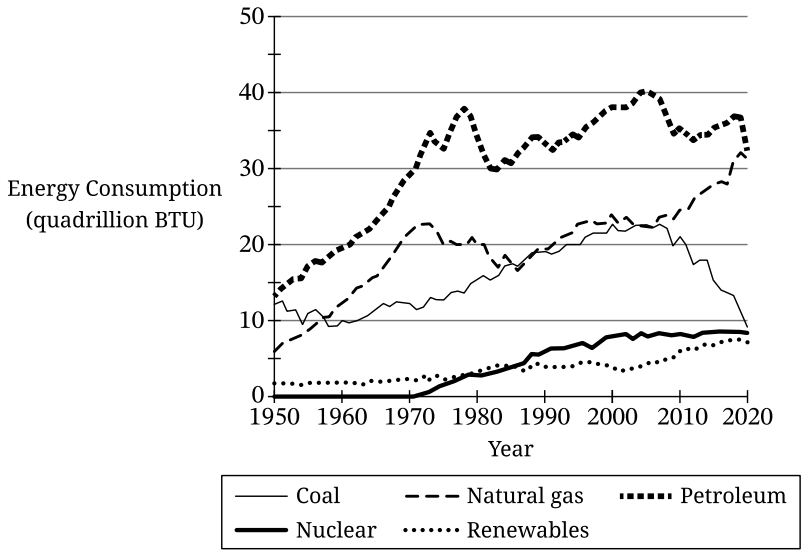
The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.

ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. Identify a type of surface mining the company could use to access the coal.

B. Describe an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses 1.064×10^4 kWh of electricity each year.

Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

STOP

END OF EXAM

3. Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

(a) **Describe** why coal is considered a nonrenewable energy source.

(b) **Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant.

(c) **Describe** one economic advantage of using natural gas, rather than coal, in producing electricity.

(d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans.

Particulate matter is another common pollutant in emissions from vehicles, coal-fired power plants, and various other sources. One size of particulates, $PM_{2.5}$, presents a particular risk to human health.

ATMOSPHERIC CONCENTRATION OF PARTICULATE MATTER IN 1990 AND 2016

Year	Average Annual Atmospheric Concentration of $PM_{2.5}$ ($\mu g/m^3$)
1990	85
2016	188

(e) **Calculate** the percent change in the average annual $PM_{2.5}$ concentration in the air from 1990 to 2016. **Show** your work.

(f) Trees can remove $PM_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $PM_{2.5}$ is 2.3 kilograms per hectare. **Calculate** the decrease in $PM_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work.

(g) Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in $PM_{2.5}$ concentration. A city experienced a 23% increase in $PM_{2.5}$ concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the $PM_{2.5}$ concentration continues to rise at an identical rate. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE
SECTION II
Time—1 hour and 30 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 this book. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples.

1. Read the following article from the *Fremont Daily Times* and answer the questions that follow.

Fremont Daily Times **May 1, 2018**

GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a "shining beacon" of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

(a) The students want to reduce the school's carbon footprint.

  (i) **Define** carbon footprint.

  (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.

  (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.

(b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.

(c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.

(d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.

(e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

   (a) Use the data below to respond to the following. For each calculation, show all your work.

Global Iron and Steel Data
1.6 billion tons of iron ore are used yearly to make pig iron.
1.2 billion tons of pig iron are produced each year.
Iron ore reserves are estimated to be 800 billion tons.
95% of iron ore that is mined is used in steel production.

   (i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

   (ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

   (iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

   Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

   (b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

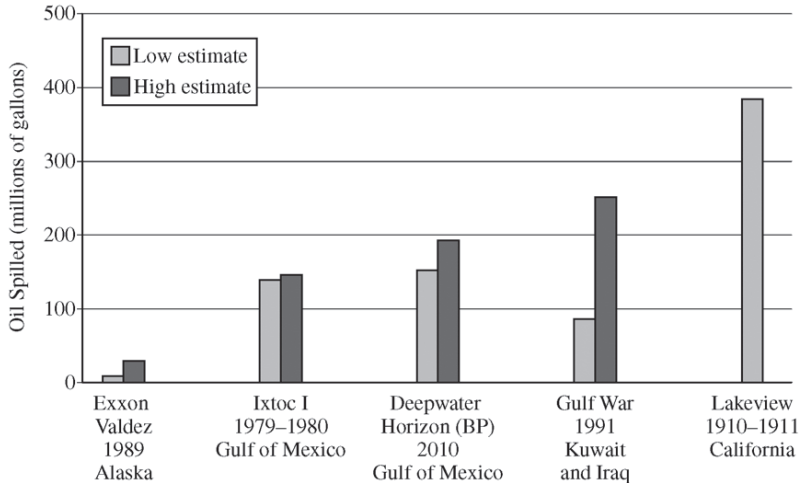
   Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

   (c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.

   (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).

   (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.

   (a) Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.

   (b) **Describe** TWO environmental problems that can result from oil spills in coastal areas.

   (c) **Identify** one economic impact that results from oil spills in coastal areas.

   (d) Chemical dispersants have been used in cleanup efforts following major oil spills.

      (i) **Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.

      (ii) **Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.

   (e) Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.

   (f) Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).