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 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 Gazette* and answer the questions that follow.

Natural Gas from Rock

The Marcellus Shale is a large domestic natural gas reserve that could meet the United States energy needs for 25 years. The 350-million-year-old geologic formation stretches from New York to West Virginia on land that is largely undeveloped. It was once thought that it was too difficult to extract natural gas from the Marcellus Shale, but new drilling technology allows energy companies to tap this vast reserve. The natural gas is removed by a process called hydraulic fracturing, or fracking. During this process, the shale is drilled and millions of gallons of water, sand, and chemicals are pumped into the shale at high pressure, shattering the shale and releasing the natural gas trapped within. While some of this water remains below ground, contaminated water is also stored in ponds, trucked to wastewater treatment plants, or disposed of by spraying it on nearby land.

(a) Identify and describe TWO water-related environmental problems associated with fracking.

(b) Natural gas is considered to be a better fossil fuel for the environment than coal is. Discuss TWO environmental benefits of using natural gas as a fuel compared to using coal.

(c) Describe TWO environmental drawbacks, not related to water use, of using the fracking process to extract natural gas from shale.

(d) Describe one economic benefit to society of using fracking to obtain natural gas from shale.

(e) Nuclear power is an alternative to using natural gas or coal as a fuel for generating electricity. However, there are also problems associated with nuclear power plants. Describe TWO negative environmental impacts associated with nuclear power.

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Question1

Read the following article from the *Fremont Gazette* and answer the questions that follow.

(a) Identify and describe TWO water-related environmental problems associated with fracking.
(*4 points: 1 point for each identification and 1 point for each description*)

Students may earn a point for either identifying a problem or describing a problem. However, if an issue is identified, it must be linked correctly to its description in order to earn 2 points.

Identification of the problem (2 points maximum)	**Description** (2 points maximum)
Groundwater contamination	• Fracking liquids or chemicals can contaminate drinking water or groundwater. • Liquid waste stored in waste lagoons can leach into groundwater (aquifer). • Drilling can allow methane (or natural gas) to seep into groundwater. • Leaks from the well casings can contaminate the water with either fracking liquids or flowback liquids. • Radioactive isotopes used as tracers in fracking fluids can contaminate groundwater.
Surface water contamination	• Brine (or wastewater) sprayed on roadways can run off and contaminate rivers, streams, and lakes. • Spills of brine (or wastewater) can contaminate rivers, streams, and lakes. • Wastewater disposed of in streams and rivers may contain salts, heavy metals, benzene, and/or other components of fracking liquid.
Excessive water use or consumption	• Considerable amounts of water are used in the fracking process. This can result in overdrafts of aquifers. • Water demands for the fracking process compete with water demands for drinking or irrigation (agriculture).

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Question 1 (continued)

(b) Natural gas is considered to be a better fossil fuel for the environment than coal is. Discuss TWO environmental benefits of using natural gas as a fuel compared to using coal.
(*2 points*)

Benefits of natural gas (must be environmental, not economic) include the following:

- Fewer SO_x are produced, resulting in less acid rain.
- Fewer NO_x are produced, resulting in less acid rain and less photochemical smog.
- Less Hg is released.
- Harmful mining techniques are avoided; for example, no strip mining or mountaintop removal is required.
- Fewer particulates (soot) are released.
- Less CO_2 is produced.

(c) Describe TWO environmental drawbacks, not related to water use, of using the fracking process to extract natural gas from shale.
(*2 points: only the first two descriptions can earn points*)

Environmental drawbacks of fracking include the following:

- Habitat fragmentation/destruction can occur from setting up the drilling site or from building roads.
- Earthquakes can result from the drilling/fracking process.
- Methane can leak (into the atmosphere) during the process, resulting in an increase of greenhouse gases.
- Subsidence of the land can occur once fracking fluids are removed.
- Trucks and drilling equipment consume a nonrenewable fuel and release CO_2 (greenhouse gases) and, potentially, SO_x (which produce acid rain) and NO_x (which produce acid rain and photochemical smog).
- Noise pollution is caused by the drilling rigs and by increased truck traffic.
- Soil salinization or heavy metal contamination can result from the spraying of wastewater.
- The drilling site increases the amount of particulate matter in the air.
- Other appropriate examples may also earn points.

(d) Describe one economic benefit to society of using fracking to extract natural gas from shale.
(*1 point*)

Economic benefits of fracking include the following:

- Development of a domestic energy resource (reducing foreign influences on price).
- Creation of jobs.
- Financial gains to individuals who lease their property to the natural gas companies.

Question 1 (continued)

(e) Nuclear power is an alternative to using natural gas or coal as a fuel for generating electricity. However, there are also problems associated with nuclear power plants. Describe TWO negative environmental impacts associated with nuclear power.
(*2 points*)

Negative environmental impacts of nuclear power include the following:

- Spent nuclear waste (fuel): a storage facility does not exist for high-level waste; waste has to be stored for 10 half-lives in order to be considered safe.
- Thermal pollution from cooling operations (impacting surface waters).
- Nuclear accidents/plant failures: release of radioactive substances, resulting in contamination of soil, water, air, and living organisms.
- Results of mining uranium:
  - Habitat degradation.
  - Radioactive mine tailings.
  - Large amounts of water are used.
  - CO_2 is released during the transportation and enrichment process (from fossil fuels).
- Uranium is a nonrenewable resource.
- Limited life span: plants have to be decommissioned.
- Runoff into surface waters during construction.
- Waste produced during the enrichment process.
- Nuclear energy production is less efficient than a coal-burning power plant; most uranium ends up as waste.