AP® ENVIRONMENTAL SCIENCE
2012 SCORING GUIDELINES

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).

AP® ENVIRONMENTAL SCIENCE
2012 SCORING GUIDELINES

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.

/A/

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.

a) Two water-relaked environmental problems ~~assoc~~ associated with fracking are contamination of ground water and contamination of lakes and streams. Fracking can

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

groundwater (extremly strong acids)
contaminate^ when the chemicals^ poured on the Shale runoff the rock and enter underground aquifers. These aquifers would be used as drinking ~~the~~ water, but since they are contaminated the water is no longer usable. These same chemicals can ~~a~~ enter lakes and streams. The acid^ from the chemicals releases Al+ ions from the ~~sediment~~ rocks, which decreases fish egg viability and respiration in ~~eg~~ aquatic species, causing many life forms to die off in the contaminated area.

b) Two benafits of using gas over coal is it burns cleaner (less particulate matter) and it does not release as much mercury when burned, as coal does. Coal releases large quantities of particulate matter (PM10) when burned. These particulates contribute to industrial smog and can cause asthma and bronchitis, natural gas burns cleaner, reducing the risk of resperatory probiems. Coal also releases mercury when burned. The mercury ~~from~~ builds up ~~in~~ as it travels through the food chain (~~to~~ bioamplification) and caused nervous system/brain malfunction in humans and other top consumers. Natural gas poses much less risk of mercury consomption then coal.

c) Two environmental drawbacks of using fracking

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are the energy use needed to power the machines and the unused natural gas that is released and wasted. In order to power the machines needed ~~to fra~~ for fracking & to transport the workers and the natural gas energy is needed. This energy often comes from oil, which when burned releases CO_2, a potent greenhouse gas that contributes to global warming. Fracking also results in natural gas that is released and wasted. Natural gas (CH_4) is also a potent greenhouse gas, ~~that~~ that contributes to global warming.

d) One economic benefit to using fracking ~~are~~ the jobs created. Workers are needed to transport materials, opperate machinery, and transport the natural gas. Using fracking employs many people, positively impacting the economy.

e) Two negative environmental impacts of nuclear power are thermal pollution and the question of what to do with the radioactive waste. In order to cool down nuclear reactors, water from adjacent Streams/rivers ~~are~~ is used. This water

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

is circulated back into the body of water at higher temperatures, which lowers the DO concentration, causing many fish species who need high DO (disolved Oxygen) concentrations to die out. Another environmental problem of nuclear power is the radioactive waste that is created. This waste lasts for thousands of years and there is no solution without drawbacks as to where to store ~~these~~ the ~~wastes~~ radioactive waste.

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1B1

ENVIRONMENTAL SCIENCE

SECTION II

Time—90 minutes

4 Questions

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(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.

A) One water-related environmental problem associated with fracking is the contamination of fresh groundwater. The contamination results in unsafe tap water ~~with~~ that holds flammable gases. Another environmental

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

problem is the depletion of fresh water to obtain the natural gas. Millions of gallons of fresh water must be used to shatter the shale to gain access to the natural gas. The use of ~~so~~ the large quantity of water needed depletes sources and the released water is now contaminated.

B) Natural gas would be more beneficial to the environment because the burning of natural gas does not ~~is~~ release sulfur emissions which cause acid deposition. Another environmental benefit of natural gas is that it does not emit as much carbon as coal does. Carbon dioxide, a greenhouse gas, increases the rate of climate change so decreasing the amount of carbon dioxide released would benefit the environment by decreasing the rate of climate change.

C) An environmental drawback to fracking would be the amount of habitat destruction it requires to gain access to the natural gas. The land spans from New York to West Virginia ~~pennsylvania~~ and is underdeveloped, which means much of the land is unaffected by human development. Drilling into the land means disrupting the natural ecosystem and displacing the organisms due to the habitat destruction. Another environmental drawback would be the amount of pollutants associated with fracking. In order to access the natural gas, water, sand, and chemicals must be used to drill through the shale. The chemicals pollute the surrounding area and land, disrupting

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

the ecosystem.

D) An economic benefit of natural gas is that the access to another fuel source would decrease the demand of coal ~~therefore~~ thereby decreasing the cost of coal. This would make energy cheaper and more accesible.

E) An environmental problem associated with nuclear power is the ~~transportation~~ transportation and placement of the waste, which is radioactive and very high in temperature. Another negative environmental impact of nuclear power is that the instability of the power source could result in disastrous consequences if the power plant's safety mechanisms fail, such as with radioactive contamination.

1C1

ENVIRONMENTAL SCIENCE
SECTION II
Time—90 minutes
4 Questions

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(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.

a.) Aquifier contamination from chemicals used for fracking is a major issue. The high-pressure fracturing may expose aquafiers to chemicals which can contaminate drinking water. Another issue is water source

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

depletion. Fracking requires the use of huge amounts of water. If this water is taken from local bodies of water, the local bodies will be depleted. b.) Natural gas burns more completely than coal. This means that it will release fewer airborne pollutants. Extraction of coal requires mining which damages huge amounts of land. Natural gas extraction requires much less of land. c.) Natural gas is a non-renewable source of energy. It will eventually run out and increase our demand for other sources of energy. Unlike clean sources such as solar power or hydroelectric power, natural gas combustion releases pollutants into the atmosphere. d.) Natural gas is present in the United States. Therefore, we would not have to rely on foreign imports for our energy. This would boost U.S. reliance on American power companies which will boost our economy. e.) Disposal of fuel rods used in nuclear reactors first requires cooling pools. The water used for these pools becomes irradiated and, if not disposed of carefully, can be reintroduced to ground or surface water and pollute them. Also, huge amounts of water must be used to cool down steam used for spinning a turbine. The cooling water is heated and returned to its original source. This will increase the temperature of that body of water which will damage aquatic life.

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AP® ENVIRONMENTAL SCIENCE
2012 SCORING COMMENTARY

Question 1

Overview

This question was based on a mock newspaper article. The article described hydraulic fracturing (fracking) as a means of obtaining natural gas from the Marcellus Shale. Students were asked to identify and describe two water-related environmental problems associated with fracking and were later asked to describe two non-water-related environmental drawbacks associated with using the fracking process to extract natural gas from shale. The students were also asked to identify one economic benefit to society of using this process to obtain natural gas. Additionally, students were asked to discuss two environmental benefits of using natural gas instead of coal and to describe two negative impacts associated with nuclear power.

Sample: 1A
Score: 10

Three points were earned in part (a). Two points were earned for identifying groundwater contamination and "contamination of lakes and streams" as two problems associated with fracking. A third point was earned for describing drinking water contamination as a result of groundwater contamination. Two points were earned in part (b) for the discussion of how natural gas releases "less particulate matter" and less mercury when combusted than coal does. Two points were earned in part (c) for describing how the trucks used for transporting workers and product consume oil, "which when burned releases CO_2, a potent greenhouse gas." The student also notes that natural gas can leak out during the process and that "[n]atural gas (CH_4) is also a potent greenhouse gas." One point was earned in part (d) for stating that one economic benefit of fracking is job creation. Two points were earned in part (e) for describing the impact on aquatic systems associated with the thermal pollution produced by nuclear power plants and for describing the problems with the storage of spent nuclear waste.

Sample: 1B
Score: 8

Three points were earned in part (a). Two points were earned for identifying contamination of groundwater as a problem and for describing how contamination of this water source "results in unsafe tap water." Another point was earned for identifying excessive water use as a problem. Two points were earned in part (b): 1 point for discussing how the burning of natural gas (rather than coal) results in lower "sulfur emissions which cause acid deposition" and 1 point for explaining that the use of natural gas decreases "the amount of carbon dioxide released." One point was earned in part (c) for describing "habitat destruction" as an environmental drawback of fracking. No points were earned in part (d). Two points were earned in part (e) for describing problems with the "transportation and placement" of radioactive waste and for describing how, if an accident occurred at a nuclear power plant, radioactive contamination would result.

Question 1 (continued)

Sample: 1C
Score: 6

Three points were earned in part (a). Two points were earned for identifying groundwater contamination as a problem and for describing how drinking water would be contaminated. One point was earned for identifying excessive water use as another water-related problem with fracking. No point was earned for the reference to the depletion of local bodies of water, because the description is too vague. No points were earned in parts (b) or (c), because the responses are not specific. One point was earned in part (d) for describing how natural gas from fracking would decrease our reliance on foreign sources of energy. Two points were earned in part (e) for describing the problems of safely disposing of spent nuclear fuel (fuel rods) in cooling pools and for describing how thermal pollution impacts surface waters.