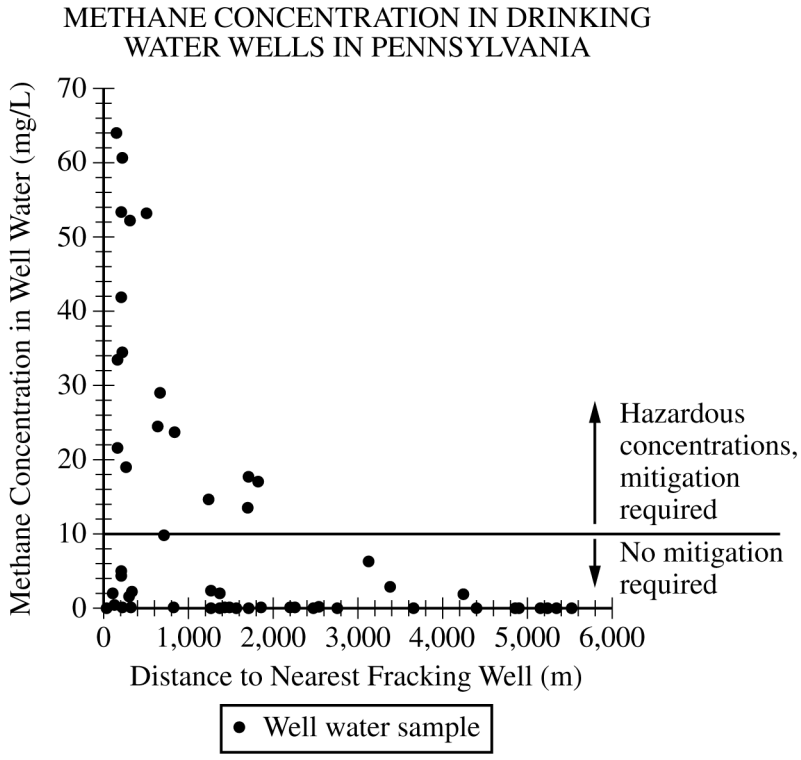
2. Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.



(a) The graph shows the methane concentration in drinking water from home wells and the distance to the nearest fracking well in Pennsylvania.

(i) Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania.

(ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well.

(iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well.

(iv) **Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process.

(v) **Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.

(b) The volume of water used for oil and gas extraction is 28 times greater than it was fifteen years ago. Much of the water used for oil and gas extraction comes from groundwater sources in arid or semiarid regions. This increased use of water for fracking may mean that less water is available for local use.

(i) The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource.

(ii) **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions.

(iii) **Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption.

GO ON TO THE NEXT PAGE.

(c) In addition to water quality issues caused by fossil fuel extraction, air quality can also be negatively affected by combustion of oil and natural gas.

(i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil.

(ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change.

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.

GO ON TO THE NEXT PAGE.

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

(a) (i) Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania. **1 point**

- 64 mg/L

(ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well. **1 point**

Accept one of the following:

- Methane concentration decreases as distance from the fracking well increases.
- Methane concentration increases as distance from the fracking well decreases.
- There is an inverse/nonlinear relationship/negative correlation between the two variables.

(iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well. **1 point**

Accept any value between:

- 1,800 – 2,200 meters

(iv) **Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process. **1 point**

Accept one of the following:

- Fracking fluid is injected/pumped into the well under high pressure, opening rock fissures, releasing oil and natural gas.
- Sand grains in the fracking fluid hold the newly formed cracks/fractures open to allow the oil and natural gas to flow up the well.

(v) **Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs. **1 point**

Accept one of the following:

- Earthquakes/seismic activity
- Ground subsidence/sinkholes

Total for part (a) **5 points**

(b) (i) The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource. **1 point**

- Tragedy of the Commons

	depletion/contamination from fracking/drilling operations • Decreased oil consumption which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
Increase gasoline tax/reduce oil subsidies	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
	Total for part (c)	**2 points**
	Total for question 2	**10 points**