



AP[®] Environmental Science 2009 Free-Response Questions

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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. 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 article below from the *Fremont Free Press* and answer the questions that follow.

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Fremont City Council Considers Nitrogen Ban to Fight Smog!

At Tuesday's council meeting, Susan Lanza, a local environmental scientist, spoke about the role that nitrogen compounds play in the photochemical smog episodes that have recently plagued Fremont. Noting how successful the ban on the sale of phosphate detergents had been in improving conditions in Lake Fremont, Councilman Peter Budd proposed a ban on the use of all nitrogen-containing

fertilizers in Fremont to solve the local photochemical-smog problem.

Councilwoman Nita Smith made a statement that "although nitrogen-based fertilizers can cause other environmental problems, the ban on nitrogen fertilizers won't solve the smog problem in Fremont." After a heated discussion, the council tabled the motion on the ban.

- (a) Support Councilwoman Smith's statement that nitrogen-based fertilizers cause other environmental problems by describing one such problem.
- (b) Identify a nitrogen-containing primary pollutant that contributes to the formation of photochemical smog. Describe how that primary pollutant forms and explain why Councilman Budd was wrong.
- (c) Identify one secondary pollutant that is a component of photochemical smog and describe the following.
- How the secondary pollutant forms
 - ONE human health effect of the pollutant
 - ONE environmental effect of the pollutant
- (d) Earth's natural nitrogen cycle occurs in several steps. Describe one chemical transformation that occurs in the natural nitrogen cycle and discuss the importance of that transformation to an ecosystem.

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2. Anaerobic methane digesters have been used for many years to reduce energy costs on farms throughout Europe and on some large farms in the United States. The digesters operate by using anaerobic bacteria to break down animal waste. During the process, which typically uses a tank heated to about 100°F (38°C) to speed the reactions, raw manure is broken down and methane is produced. The methane can then be used to generate electricity or produce heat.

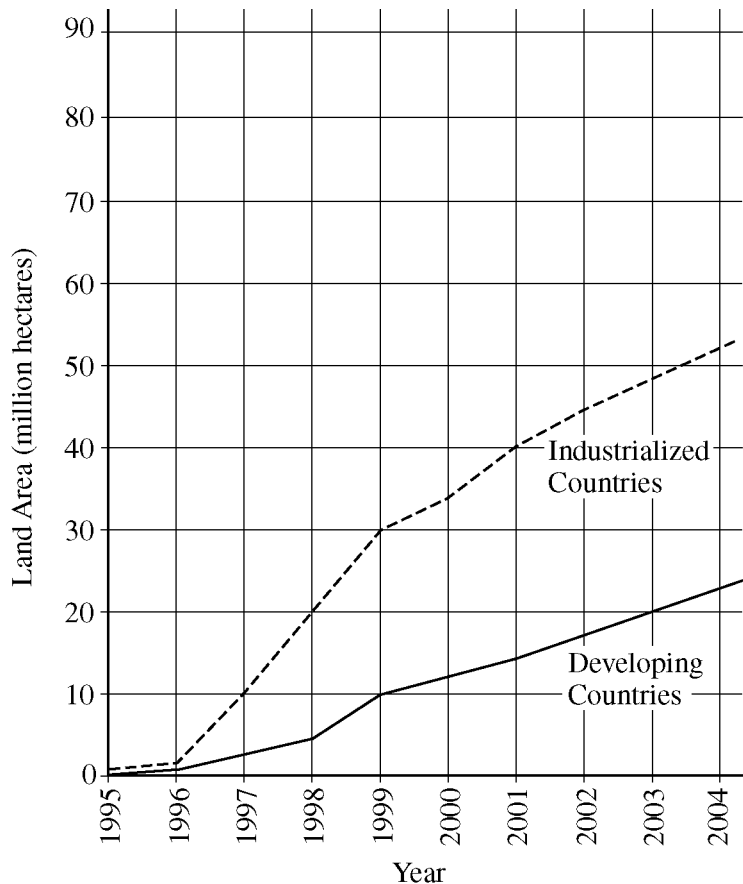
For a certain dairy farm with 500 cows, the cost of installing a digester is approximately \$400,000. Assume that the farm uses 800,000 kilowatt-hours (kWh) of electricity each year at a cost of \$0.10 per kWh. The waste from a single cow can produce 3.0 kWh of electricity each day.

- (a) Describe the steps by which methane produced in the digester can be used to generate electricity.
 - (b) Discuss TWO environmental benefits that may result from the installation of an anaerobic methane digester.
 - (c) Assuming that the cost of electricity remains constant and the farmer starts using the manure from the cows in an anaerobic digester to produce electricity on the farm, calculate:
 - (i) The number of kWh of electricity that can be produced in one year
 - (ii) The amount of money the farmer can save in one year, NOT counting the installation cost of the digester. (You may round your answer to the nearest \$1,000.)
 - (iii) The amount of time, in years, that it will take to recover the cost of installing an anaerobic digester on the farm. (You may round your answer to the nearest whole number of years.)
 - (d) Calculate the minimum number of cows the farm would need to produce 800,000 kWh of electricity per year.
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3. The Colorado River flows from the Colorado Rockies to the Gulf of California. The primary source of Colorado River water is melting Rocky Mountain snowpack. Once the river descends from the Rockies, it flows through a landscape that is dominated by desert. Colorado River water carries a high load of sediment.
- (a) Multiple dams have been erected along the Colorado River. Identify TWO benefits other than agriculture and recreation that people derive from that system of dams.
 - (b) Discuss TWO potential environmental consequences of damming a major river.
 - (c) Competition for access to Colorado River water has increased dramatically due to increased population size and intensive agricultural use. Describe TWO conservation strategies for reducing agricultural water consumption.
 - (d) Identify TWO possible environmental consequences of climate change on the hydrology of the Colorado River system.
 - (e) In addition to impacts on the Colorado River system, climate change is impacting the hydrology of coastal ecosystems. Identify and describe TWO possible consequences of climate change on coastal ecosystems.

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4. The major issues in modern agriculture include the use of genetically modified (GM) crops and the implementation of sustainable agricultural practices. The following graph shows the increase in the use of GM crops in both developing and industrialized countries from 1995 to 2004.



- (a) Reply to the following questions based on the data in the graph above.
- Calculate the increase in the area of land used for growing GM crops in developing countries from 1999 to 2003. Express your answer as a percentage of the 1999 value.
 - Calculate the annual rate of increase in land area used for growing GM crops in industrialized countries from 1997 to 1999.
 - Using the rate you calculated in part (ii), project the area of land that would have been expected to be used for GM crops in industrialized countries in 2004.
 - Identify one likely cause for the difference between the projected land area for GM crops in industrialized countries in 2004 and the actual land area for GM crops in industrialized countries in 2004.

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- (b) Describe one environmental advantage and one environmental disadvantage of using GM crops.
- (c) Describe one economic advantage and one economic disadvantage of using GM crops.
- (d) A healthy soil ecosystem is of primary importance in sustainable agriculture. Describe TWO viable agricultural practices that farmers can use to maintain or improve soil quality.
- (e) Identify and describe one environmental advantage and one economic advantage of consuming locally grown produce.

STOP

END OF EXAM