

2004 AP[®] ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

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 editorial below and answer the questions that follow.

14 FREMONT INQUIRER

Is the Seafood We Eat Safe?

Poisonous mercury is on our dinner plates everywhere - in sea bass served in fancy restaurants, in tuna casserole ladled out at home. Most of the time it is harmless, but eat enough and it can make you sick. Too much mercury can damage the nervous system, especially the brain, and too much in pregnant and breast-feeding women can hurt their babies - adversely affecting children's intelligence, coordination, and memory. But how much is too much? Are adults at risk as well? Public concern about these questions is prompting public-health officials to look more seriously at mercury in the environment

and its effects. Because there are no conclusive long-term studies on humans, government officials disagree on what constitutes safe exposure levels. There are those who say mercury in seafood is a very real menace and a major threat to child development. Burning fossil fuel releases mercury into the environment and this will only get worse as our dependence on coal increases. Others say the threat is overblown and that the benefits of eating fish far outweigh the worries. The fact is, no one knows.

- (a) On the basis of the article above, indicate one human activity that releases mercury into the environment. Describe how mercury is transported from that source and enters aquatic systems, often hundreds of miles away.
- (b) Describe TWO ways that the amount of mercury released into the environment from the source in part (a) could be reduced.
- (c) Explain why there are greater health risks associated with eating large predatory fish, such as tuna and sea bass, than from eating small nonpredatory fish.
- (d) Identify a toxic metal other than mercury that has a negative impact on human health and describe how it is introduced into the environment. Describe an acute sublethal effect on humans that results from exposure to this metal.

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Question 1

- (a) On the basis of the article above, indicate one human activity that releases mercury into the environment. Describe how mercury is transported from that source and enters aquatic systems, often hundreds of miles away.**

(3 points maximum out of a possible 4)

1 point for naming “the burning of coal” as the human activity that releases mercury into the environment, as mentioned in the document.

- Only the first type of fossil fuel indicated in the answer will be considered. If the wrong source is named (e.g., petroleum products) students will not earn any points in part (a).
- “Fossil fuel” alone, while not wrong, is unacceptable because mercury is a contaminant primarily in coal, and the document directs the student’s attention to it.
- If students use “power plants/industry,” they must indicate that coal is used.

1 point for describing how mercury is transported.

- Answers related to air transport should indicate the movement of air, wind, or air currents, since “goes into the air” does not include the idea of “transport.”
- A reference to incorporation of the atmospheric mercury into the water cycle may be used to earn this point, but cannot be counted as the “aquatic systems entry” point without further elaboration.
- A student who uses “coal washing” at the power plant as the actual source of mercury pollution must describe how the water is transported from that site.

1 point for describing how mercury enters aquatic systems from the source described above.

“Aquatic systems” can include the abiotic and/or the biotic components of the system. If students discuss soil as an entry point, they must explain how mercury gets from soil to water (e.g., by erosion or leaching). Examples of acceptable answers are:

- falls as dry particles into water or onto soil
- falls with rain/precipitation into water or onto soil
- enters water and becomes incorporated into food chains
- could enter groundwater/surface water from the coal-washing process
- could enter streams and rivers from groundwater

1 possible elaboration point for an answer that indicates an unusual depth of knowledge about the subject, by making points such as:

- three states of mercury—particulate, elemental, and an oxidized form
- microorganisms in the soil and water can convert inorganic mercury into an organic form, methyl mercury, in which form it can readily enter food chains

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Question 1 (cont'd.)

- (b) Describe TWO ways that the amount of mercury released into the environment from the source in part (a) could be reduced.**

(2 points maximum)

Note: If a student mentions “coal” in both parts of this answer, and if no specific “fossil fuel” was given in part (a) above, the student may earn the point for “the burning of coal” in part (a) if the answer is otherwise satisfactory.

1 point each for describing two of the methods given below.

- Only the first two answers will be considered.
- Simply naming a method is not enough; the answer should describe how this would result in a decrease in mercury by providing concrete examples, developing a rationale, or describing a process.
- Only one point will be earned for multiple examples of the same argument, e.g. solar and wind energy as alternatives to coal.

Reduce the amount or change the type of fossil fuel burned

- burn higher-rank coals but with equivalent (or lower) mercury content, thereby generating more BTUs per unit amount of coal
- burn coal with equivalent or better rank, but with lower mercury levels
- use another kind of fossil fuel with lower mercury content, such as natural gas
- switch to a power-generating system (wind, solar, hydroelectric, etc.) that has a much lower or non-existent mercury contamination component
- make furnaces burn more efficiently (any of a variety of methods)

Pre-combustion removal of mercury:

- wash the coal (physical density separation or chemical cleaning)

Post-combustion removal of mercury

- use sorbents such as activated carbon, calcium, sodium tetrasulfide, or silicates which convert the gaseous mercury into an insoluble, thermally stable solid compound that can then be removed by using electrostatic precipitation, wet scrubbers, baghouse, fabric filter, or other particulate removal device (gaseous mercury must be converted before any of these other control methods can be effective, so “scrubbing” or “filtering” alone is not enough)
- use catalyst systems that oxidize elemental mercury, which can then be removed, by wet lime or limestone flue gas desulfurization (FGD) systems
- cool the flue gas and capture fly ash

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Question 1 (cont'd.)

Other

- enforce the Clean Air Act, stop exempting utilities from mercury control regulations, obtain international agreements, enact legislation to require controls, or the like (must include discussion of any of these chosen)
- use tax incentives or other means of encouraging voluntary reductions (must include discussion)
- conserve energy, reduce consumer demand, or the like (must include discussion)

(c) Explain why there are greater health risks associated with eating large predatory fish, such as tuna and sea bass, than from eating small nonpredatory fish.

(3 points maximum)

1 point for discussing why there would be more mercury in predatory vs. nonpredatory fish.

This explanation should be based on the idea of bioaccumulation/biomagnification and may include concepts such as:

- food chains or webs/trophic levels
- mercury transfers to higher trophic levels
- the concentration of mercury increases in higher trophic levels

1 point may be earned for discussing the relationship of size, long lifespan, and the accumulation of mercury.

For example: over the course of a lifetime, older fish have had more time to accumulate significant amounts of mercury, regardless of their trophic level.

This point also could be earned for a discussion of absorption through the skin/gills as it is related to the accumulation of mercury over a longer lifetime.

1 elaboration point is possible for an in-depth explanation of bioaccumulation/ biomagnification, or for a good explanation of one or more of the following topics:

- mercury is stored in fat/muscle and cannot be removed easily by body enzymes
- mercury can enter food chains by being converted to methyl mercury [no credit earned here if already earned in part (a)]
- explains the difference between bioaccumulation and biomagnification

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Question 1 (cont'd.)

- (d) Identify a toxic metal other than mercury that has a negative impact on human health and describe how it is introduced into the environment. Describe an acute sublethal effect on humans that results from exposure to this metal.**

(3 points maximum) Consider only the first metal and the first effect given.

1 point for naming a toxic metal, 1 point for describing how it is introduced into the environment, and 1 point for describing a sublethal effect on humans. If no toxic metal was identified, no points could be earned in this part. (Lead was the most common answer given; following is the rubric used for lead. Many other metals could be used to earn credit in this part.)

How Lead Is Introduced (read all for a correct answer)	Effects of Lead on Human Health
Industry: mining and refining processes Consumer goods: batteries cigarette smoke coal combustion colored inks cosmetics electronics firing ranges/bullets food (esp. candy) gasoline additives hair dyes insecticides paint pottery glazes plumbing radiator repair shops TV picture tube toothpaste volcanic eruptions window blinds wine	abdominal pain adrenal/liver/kidney dysfunction allergies anxiety autism birth defects/toxic to the fetus blindness bones/joint pain and weakness/arthritis cardiovascular disease colic constipation convulsions depression dizziness/headache/fatigue/nausea dyslexia epilepsy GI symptoms gout hallucination/mood swings/nightmares/poor concentration/psychosis hyperactivity immune system depression impotence

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Question 1 (cont'd.)

Effects of Lead on Human Health (cont'd.)
menstrual problems multiple sclerosis muscular dystrophy neurological effects/brain development and function/ hostility/hypertension/learning disorders/mental retardation/numbness Parkinson's disease prostate enlargement red blood cell/anemia/enzyme function restlessness stroke