

Week 23

AP Environmental Science

Homework bundle for this week

本周作业合集

exercises.lol

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AP Environmental Science

Name: _____ Score: _____

1. A **point source** of pollution is...
 - ☐ one identifiable spot, like a pipe
 - ☐ spread across a whole region
 - ☐ always in the air
 - ☐ impossible to locate
2. Which human activity most directly harms an ecosystem?
 - ☐ dumping toxic waste into a river
 - ☐ planting native trees
 - ☐ protecting a wetland
 - ☐ cleaning up a beach
3. An **endocrine disruptor** is a chemical that...
 - ☐ interferes with the body's hormones
 - ☐ gives the body extra energy
 - ☐ cleans the blood
 - ☐ is completely harmless
4. A **wetland** is land that...
 - ☐ is covered or soaked with water
 - ☐ is always dry desert
 - ☐ is deep open ocean
 - ☐ is bare rock
5. Eutrophication usually starts with...
 - ☐ extra nutrients washing into water
 - ☐ water getting colder
 - ☐ less sunlight
 - ☐ removing all the fish
6. Rain washing pollutants off fields and roads into rivers is called _____.

7. Clean water, pollination, and flood control are examples of ecosystem _____.

8. Endocrine disruptors are found in some pesticides and in certain _____.

9. Wetlands act as natural _____, trapping pollutants and cleaning water.

10. When the algae die, decomposers use up the dissolved _____ in the water.

AP Environmental Science

1. **one identifiable spot, like a pipe**

A **point source** comes from one clear location — a factory pipe, a smokestack, a single spill.

2. **dumping toxic waste into a river**

Dumping toxic waste poisons water and kills the organisms living in it — direct harm.

3. **interferes with the body's hormones**

An **endocrine disruptor** interferes with hormones — the chemical messengers that control the body.

4. **is covered or soaked with water**

A **wetland** is land soaked or covered with water — marshes, swamps, and bogs.

5. **extra nutrients washing into water**

Extra **nutrients** — nitrogen and phosphorus from fertilizer — trigger the whole process.

6. **runoff**

Runoff carries diffuse pollutants off the land — the classic nonpoint source.

7. **services**

Ecosystem **services** are the free benefits nature gives us — clean water, pollination, and more.

8. **plastics**

Some **plastics** and pesticides contain chemicals that act as endocrine disruptors.

9. **filters**

Wetlands work like natural **filters**, trapping sediment and pollutants as water passes through.

10. **oxygen**

Bacteria decomposing the dead algae consume the **oxygen** fish need, so fish suffocate.

8.1 Sources of Pollution

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS point-source 点源 • nonpoint-source 非点源

Objective

Build the skills to answer exam questions on **sources of pollution**.

You must be able to:

- distinguish **point-source** 点源 and **nonpoint-source** 非点源 pollution
- give examples of each
- explain why nonpoint pollution is harder to control

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Point vs nonpoint

- **Point source** — pollution from a **single, identifiable** location (a factory pipe, a sewage outfall).
- **Nonpoint source** — pollution from **many spread-out** sources (fertilizer runoff from farms, oil from roads).

■ Why nonpoint is harder

Point sources are easy to find and regulate. **Nonpoint** sources come from a wide area, so they are hard to trace and control — the main challenge in water pollution today.

■ A worked classification

A pipe discharging waste into a river is a **point source**; fertilizer washing off thousands of farm fields is a **nonpoint source**.

■ Controlling each

Point: regulate the pipe. Nonpoint: change land-use practices (buffer strips, less fertilizer) across the whole watershed.

2 Practice

Now apply the methods above.

2.1 What is a point-source pollutant? [1]

2.2 Give one example of nonpoint-source pollution. [1]

2.3 Why is nonpoint pollution harder to control? [1]

3 Exam-style questions

3.1 Fertilizer runoff from many farms is an example of [1]

- **A** point-source pollution
 - **B** nonpoint-source pollution
 - **C** air pollution only
 - **D** no pollution
-

3.2 A river is polluted by both a factory pipe and farm runoff.

(a) Classify each source. [2]

(b) Explain why the farm runoff is harder to regulate. [2]

3.3 Suggest one way to reduce nonpoint-source pollution from agriculture. [1]

Solutions

2.1 Pollution from a single, identifiable location.

2.2 Any one: farm fertilizer runoff, road/urban runoff.

2.3 It comes from a wide, spread-out area, so it is hard to trace and control.

3.1 B — nonpoint-source pollution.

3.2 (a) Factory pipe = point source; farm runoff = nonpoint source. (b) The runoff comes from many spread-out fields rather than one pipe, so there is no single source to regulate.

3.3 Any one: buffer strips, reduced/precise fertilizer, cover crops, no-till.

ENVIRONMENTAL SCIENCE

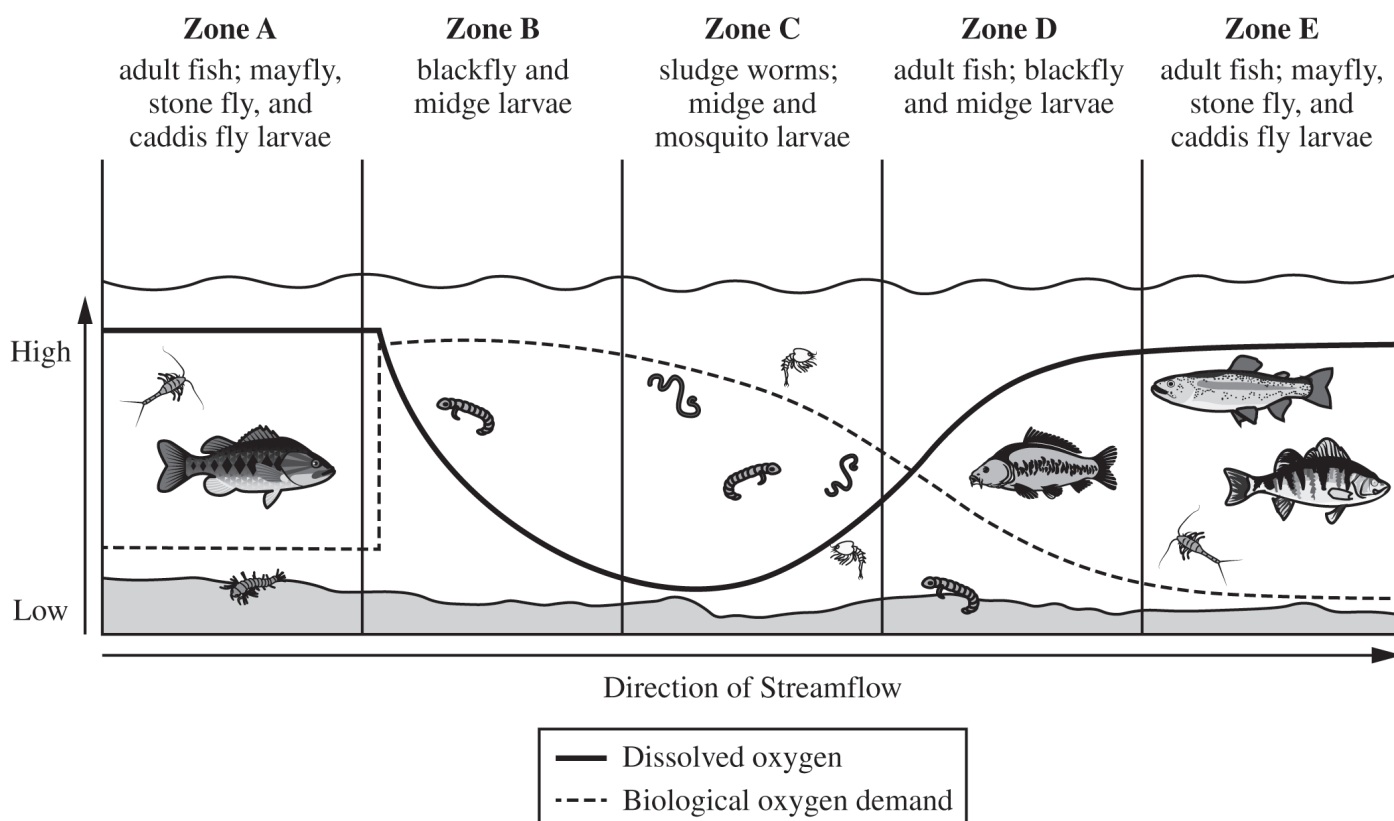
SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen..
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.
- (c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

- (d) **Identify** the dependent variable in the researchers' investigation.
- (e) **Identify** a testable hypothesis for the researchers' investigation.
- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

- (g) **Explain** how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.
- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

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.

ENVIRONMENTAL SCIENCE

SECTION II

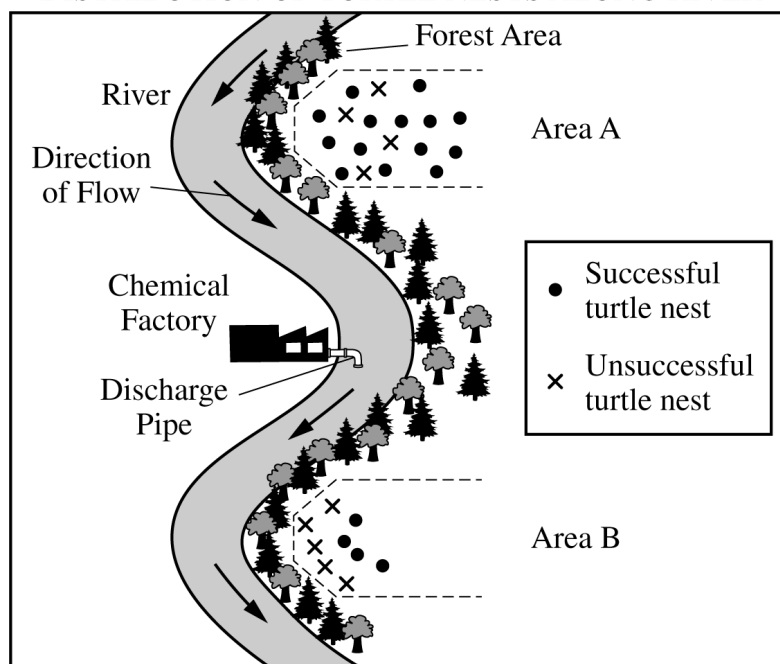
Time—1 hour and 10 minutes

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1. Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.

DISTRIBUTION OF TURTLE NESTS ALONG RIVER



- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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.

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 Daily Times* and answer the questions that follow.

Fremont Daily Times

Scientists Discuss Threats from Plastic Pollution

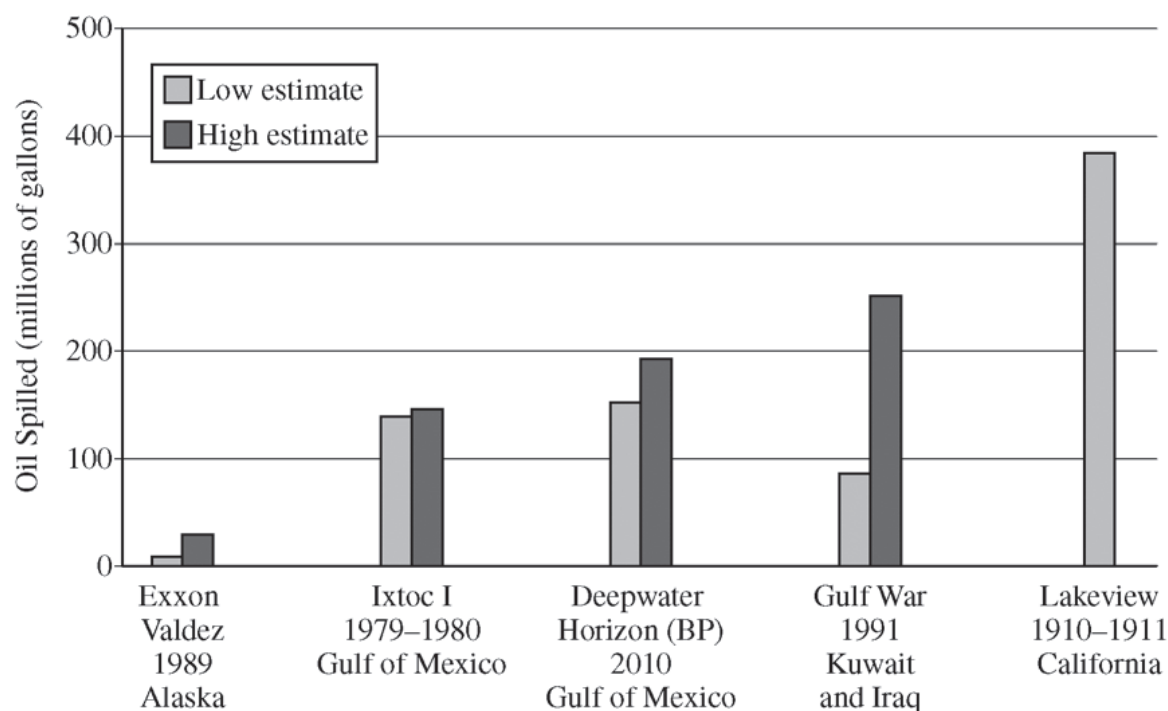
In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake

them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

- (a) **Describe** TWO effects that ingesting microbeads has on aquatic organisms.
- (b) Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. **Describe** how nitrate levels can negatively affect water quality in some aquatic ecosystems.
- (c) While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants.
- (i) **Identify** one way large pieces of plastic are removed from wastewater during primary treatment.
 - (ii) Prior to discharge, wastewater is often disinfected. **Identify** one technique commonly used to disinfect wastewater.
 - (iii) Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. **Identify** one advantage and one disadvantage of this practice.
- (d) Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem.
- (i) **Provide** one reason why mangrove trees are being removed by humans.
 - (ii) **Identify** one ecosystem service provided by intact mangrove ecosystems.

VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.
- (a) Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.
 - (b) **Describe** TWO environmental problems that can result from oil spills in coastal areas.
 - (c) **Identify** one economic impact that results from oil spills in coastal areas.
 - (d) Chemical dispersants have been used in cleanup efforts following major oil spills.
 - (i) **Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.
 - (ii) **Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.
 - (e) Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.
 - (f) Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).

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 article below and answer the questions that follow.

The Fremont Plaindealer**May 1, 2013**

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.”

Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- (i) “Nuclear power plants produce no dangerous solid waste.”
 - (ii) “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- (i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - (ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - (iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

2. Like many communities, Fremont has a combined sewer system that collects both sewage and storm water. When storm water runs into storm drains that connect to the city's sanitary sewer system, the storm water and sewage flow together to the Fremont Wastewater Treatment Plant (FWTP). During a major storm event, however, the combined volume of storm water and sewage may exceed the plant's capacity, and the overflow bypasses the FWTP. The untreated overflow is discharged into Fremont Creek along with the treated waste.

Recently parts of Fremont received 5 cm of rain in 60 minutes. The storm caused widespread flooding in the northeast section of town. Especially hard hit was the Shoppes at Fremont shopping center.

Use the data from the table below to answer the questions that follow. Show all calculations.

Fremont Water Data
The shopping center's parking lot is 200 meters long and 100 meters wide.
Fremont has an area of 10 km^2 .
Impervious surfaces cover 20 percent of Fremont's area.
The FWTP typically treats $5,000 \text{ m}^3$ of domestic sewage per day.
The FWTP has the capacity to treat $10,000 \text{ m}^3$ of combined sewage and storm water per day.

- (a) **Identify** TWO specific pollutants in storm-water runoff that degrade the quality of surface water.
- (b) **Calculate** the volume of water (in m^3) that runs off the Shoppes at Fremont parking lot after a 5 cm rainfall event. Assume that all the water that falls on the parking lot runs off.
- (c) **Calculate** the volume of storm-water runoff (in m^3) generated in all of Fremont by the 5 cm rainfall event. Assume that only the impervious surfaces generate runoff.
- (d) Assume that all the runoff that you calculated in part (c) is captured by the storm sewers in one day. **Calculate** the volume of untreated water (in m^3) that bypasses the plant as a result of the storm. (Note that the plant still receives $5,000 \text{ m}^3$ of domestic sewage per day.)
- (e) **Describe** TWO ways that the volume of storm-water runoff can be reduced.
- (f) **Describe** one environmental problem (other than pollution from runoff and from untreated sewage) that results from having extensive paved areas.

8.2 Human Impacts on Ecosystems

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS habitat fragmentation 生境破碎化

Objective

Build the skills to answer exam questions on **human impacts on ecosystems**.

You must be able to:

- describe major impacts (**habitat fragmentation** 生境破碎化, pollution, overexploitation)
- link human activity to biodiversity loss
- suggest mitigation

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Major human impacts

- **Habitat destruction and fragmentation** — roads/farms break habitat into isolated pieces.
- **Pollution** — chemicals, plastics, nutrients.
- **Overexploitation** — overfishing, overhunting.
- **Invasive species** and **climate change**.

■ Habitat fragmentation

Breaking a habitat into small, isolated pieces reduces populations, limits movement and gene flow, and raises extinction risk (like island biogeography).

■ Biodiversity loss

Together these impacts drive **biodiversity loss**, reducing ecosystem resilience and services.

■ Mitigation

Protected areas, wildlife corridors (connecting fragments), pollution limits, and sustainable harvesting reduce the impacts.

2 Practice

Now apply the methods above.

2.1 What is habitat fragmentation? [1]

2.2 Name two human impacts on ecosystems. [2]

2.3 What is a wildlife corridor for? [1]

3 Exam-style questions

3.1 Habitat fragmentation increases extinction risk by [1]

- **A** enlarging populations
 - **B** isolating small populations and limiting movement
 - **C** adding resources
 - **D** removing predators only
-

3.2 A new highway cuts a forest into isolated patches.

(a) Explain two effects on the wildlife. [2]

(b) Suggest one way to reduce the harm. [1]

3.3 Explain how wildlife corridors help populations in fragmented habitats. [2]

Solutions

2.1 Breaking a habitat into small, isolated pieces.

2.2 Any two: habitat destruction, pollution, overexploitation, invasive species, climate change.

2.3 To connect isolated habitat fragments so animals can move between them.

3.1 B — isolating small populations and limiting movement.

3.2 (a) Any two: smaller isolated populations, reduced gene flow, higher extinction risk, blocked migration. (b) Build a wildlife corridor or crossing.

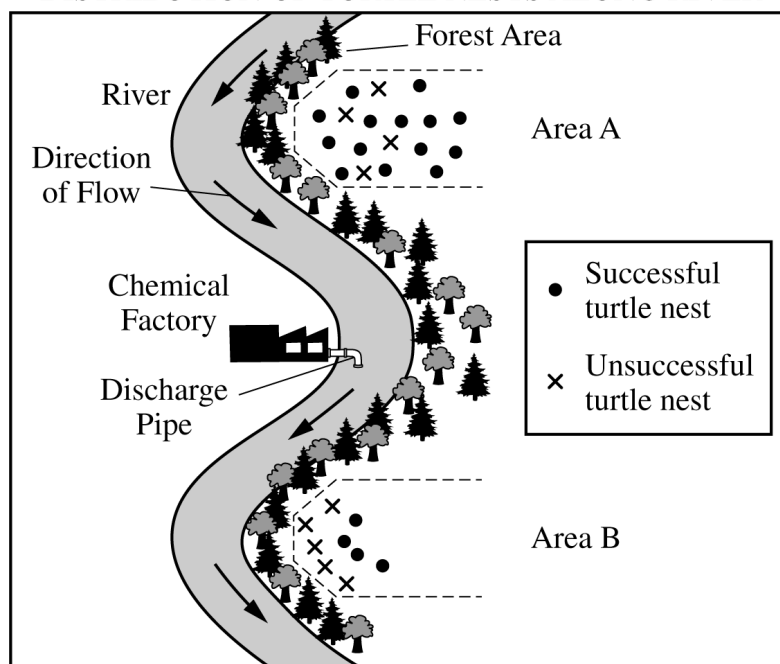
3.3 Corridors let animals move between fragments, increasing gene flow and immigration and lowering extinction risk, effectively linking the patches into a larger habitat.

ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 10 minutes****3 Questions**

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DISTRIBUTION OF TURTLE NESTS ALONG RIVER



- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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.

2. Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

- (a) Pesticide use has advantages, disadvantages, and unintended consequences on human health. **Describe** one benefit to human health that can result from the use of pesticides.
- (b) **Identify** one way chemical pesticides can enter the human body.

Cotton farmers in the southern United States used a chemical pesticide to control an insect cotton-crop pest over a 40-year period. To study the effectiveness of the pesticide as an insect pest-control strategy, traps were placed in treated cotton fields and the number of pests captured were compared to application rates for the pesticide. The results of the study are shown in the table below.

Year	Grams of Pesticide Applied per Hectare	Number of Crop Insect Pests Captured
1960	0	700
1975	500	2
1980	500	3
1985	500	8
1990	550	14
1995	600	83
2000	700	150
2005	800	405
2010	900	727
2015	1,000	1,100

- (c) Use the data in the table to answer the following questions.
- (i) **Identify** the year when the pesticide was most effective at reducing the size of the pest population.
- (ii) **Describe** the change in the number of crop insect pests in the cotton fields over time.
- (iii) **Explain** how the change in the cotton-crop pesticide effectiveness between the initial application in 1975 and the latest application in 2015 illustrates genetic resistance in pests, based on the data in the table.
- (d) **Describe** TWO effects of pesticide use, other than death, on nontarget wildlife.

- (e) There are many problems associated with the repeated application of chemical pesticides to reduce pest populations.
- (i) Crop rotation is often used to reduce pesticide use. **Describe** the process of crop rotation.
- (ii) **Propose** one reasonable method, other than crop rotation, of reducing the use of pesticides in agricultural practices while still maintaining a high crop yield.
- (iii) **Justify** how the method proposed in (e)(ii) would provide a benefit to humans.

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.

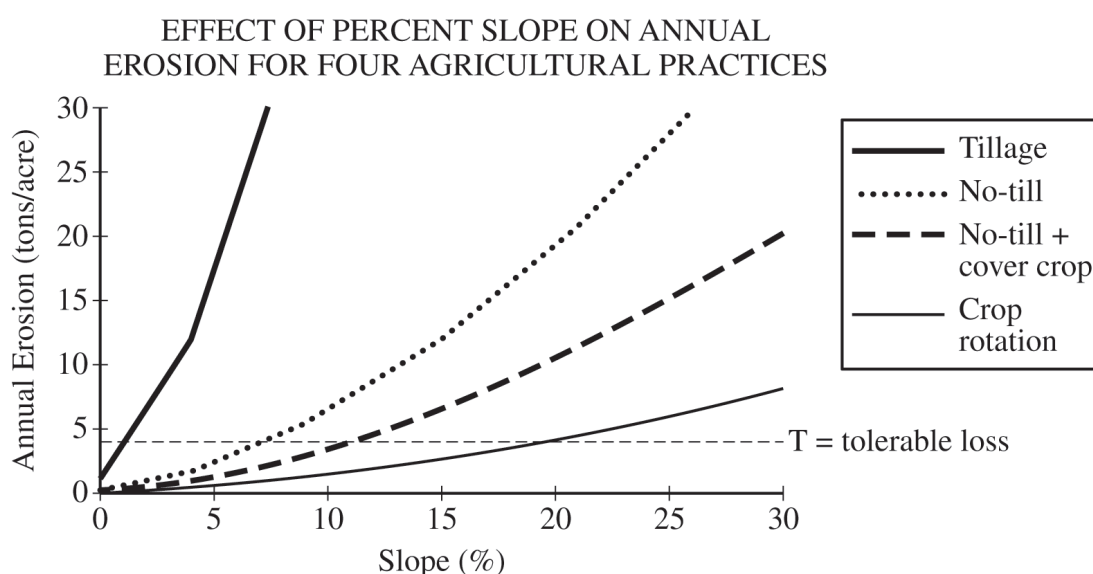
ENVIRONMENTAL SCIENCE

SECTION II

Time—1 hour and 10 minutes

3 Questions

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1. Soil erosion is one of the most serious soil-degrading processes. Each year tons of soil erode from cropland, pastures, forests, and other places. The amount of erosion varies dramatically among various land-use types. The figure above shows the effects of different agricultural practices and slopes on annual erosion rates.

(a) Refer to the graph above for the following.

- Identify** the scientific question that resulted in the data presented in the graph.
- Identify** the agricultural practice that could be used on a 15% slope without leading to a higher than tolerable loss of soil.
- Describe** the effect of adding a cover crop compared to using the no-till method.
- Identify** one natural mechanism of soil erosion.

(b) Sediment from erosion can enter streams and affect water quality. One way sediment can enter a stream is from nearby road construction. Two methods to reduce sediment run-off in streams are to either put down straw bales or plant grass. The hypothesis to be tested is that straw bales reduce more sediment run-off than planted grass does. To test the hypothesis, two plots near a road under construction are measured. On one plot (A), straw bales are used to cover the soil, while a second plot (B) is planted with grass. The sediment discharge from each plot is measured after rainfall.

(i) **Identify** the dependent variable stated in the hypothesis.

(ii) **Describe** one way to add a control to improve the design of the study.

(iii) **Identify** one variable that was not discussed that could affect the results of the study.

Sediments reaching streams affect water clarity, which is tested by determining turbidity. Turbidity can be determined by measuring the depth at which a submerged object can no longer be seen from the surface.

Sample Group	Turbidity
Straw bale plots (plot A)	12 cm
Planted grass plots (plot B)	28 cm

(iv) Based on the data in the table above, **make a claim** about the stated hypothesis.

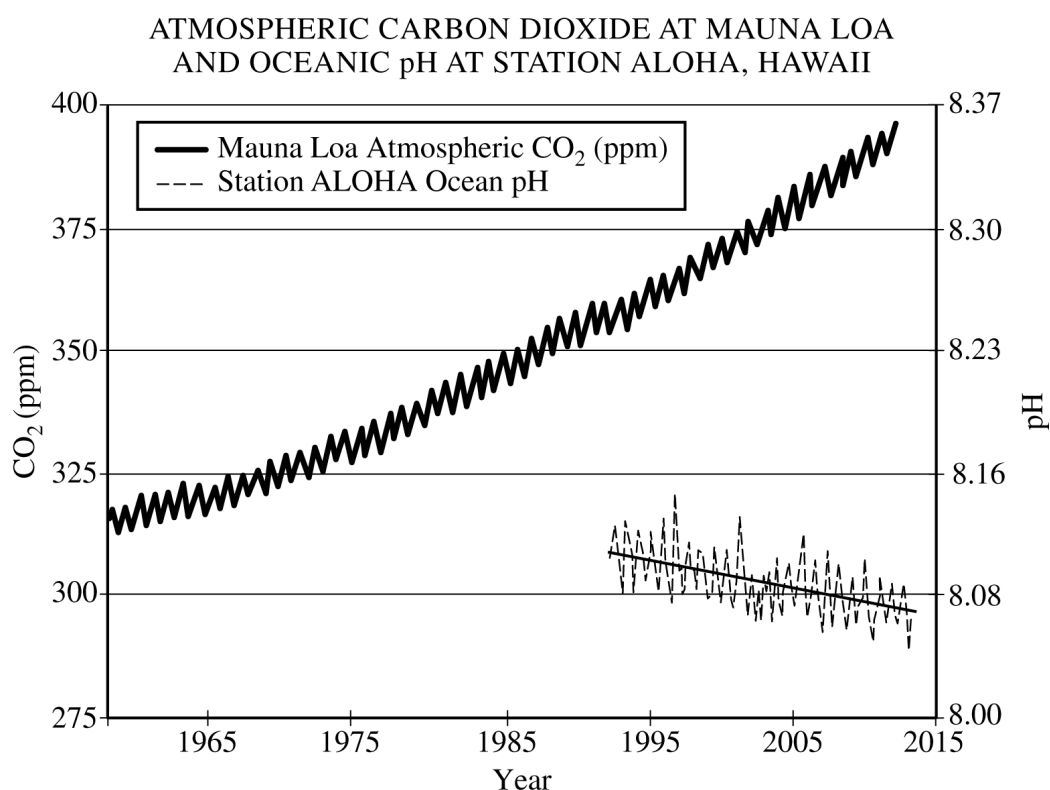
(c) Several fish species lay their eggs in the gravel in the streams under investigation in the study.

(i) **Describe** the type of survivorship curve expected for these fish species.

(ii) **Explain** why the input of sediment to a stream can negatively affect reproduction of fish that lay their eggs in the gravel of the streambed.

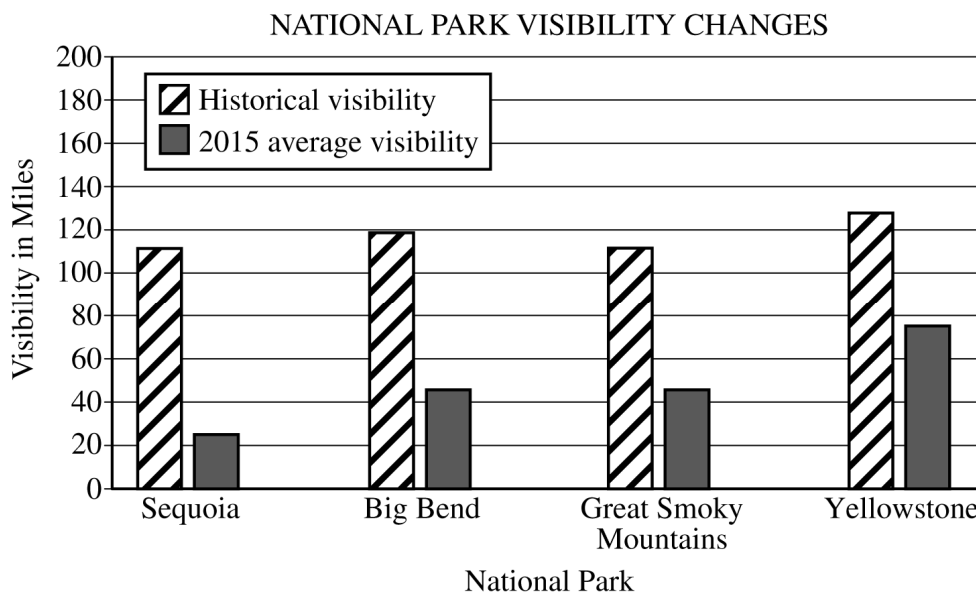
Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

3. The graph shows measurements of atmospheric levels of carbon dioxide (CO_2) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.



- (a) Use the graph above to answer the following questions.
- Determine** the concentration of CO_2 (in ppm) recorded at Mauna Loa in 2005.
 - Determine** the pH recorded at Station ALOHA in 2005.
- (b) Changes in atmospheric carbon dioxide affect Earth's oceans.
- Predict** the effect of increased concentration of atmospheric CO_2 on the concentration of CO_2 in the ocean.
 - Based on the data, **identify** the relationship between the concentration of atmospheric CO_2 and the pH of ocean water.
 - Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO_2) and water (H_2O).
 - Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.
- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.
- Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.
 - Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystems and **describe** how the threat damages the coral reefs and coral reef ecosystems.

4. One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles away from national parks.



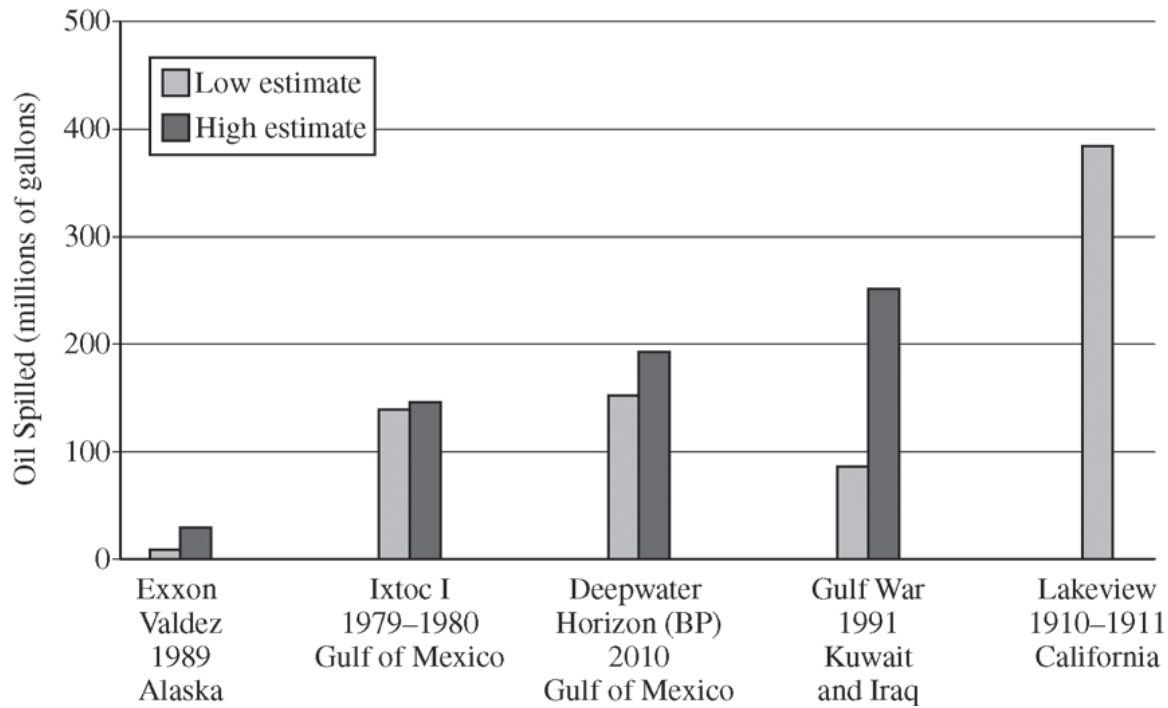
- (a) Based on the data provided in the graph, **identify** the national park that had the greatest loss of visibility as of 2015 when compared with the historical natural visibility.
- (b) Visibility in national parks can be affected by many different air pollutants.
- Identify** a primary air pollutant.
 - Describe** how a primary air pollutant becomes part of the atmosphere.
 - Identify** a secondary air pollutant.
 - Describe** how a secondary air pollutant is formed within the atmosphere.
- (c) In 1990 Great Smoky Mountains National Park had a visibility of 25 miles. Visibility data for 2015 can be determined from the graph above.
- Calculate** the percentage increase in visibility from 1990 to 2015.
 - Discuss** TWO specific actions that the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park.
- (d) Excluding air pollution, **discuss** TWO additional ways national park ecosystems are being degraded by high levels of visitor use.

STOP

END OF EXAM



VOLUME OF OIL RELEASED IN SELECTED INCIDENTS



3. Oil spills can be devastating in scope and damage. Since 1900, there have been many oil spills around the world that have had significant ecological and economic impacts.
- (a) Using the data in the graph above, **determine** the maximum volume of oil estimated to have been spilled during the Deepwater Horizon (BP) incident.
 - (b) **Describe** TWO environmental problems that can result from oil spills in coastal areas.
 - (c) **Identify** one economic impact that results from oil spills in coastal areas.
 - (d) Chemical dispersants have been used in cleanup efforts following major oil spills.
 - (i) **Discuss** both one advantage and one disadvantage of the use of chemical dispersants for oil spill cleanup.
 - (ii) **Identify** either one biological or one physical method (other than chemical dispersal) used for oil spill cleanup in coastal waters or on beaches and **describe** how the method is used.
 - (e) Catastrophic spills make up less than 20 percent of the oil that pollutes marine waters. **Identify** one other source of oil contamination and **explain** how the oil from this source enters marine waters.
 - (f) Petroleum has many uses as a raw material for consumer goods. **Identify** one substitute for petroleum in a specific consumer product (other than fuel).

8.3 Endocrine Disruptors

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS endocrine disruptor 内分泌干扰物

Objective

Build the skills to answer exam questions on **endocrine disruptors**.

You must be able to:

- define an **endocrine disruptor** 内分泌干扰物
- explain how they interfere with hormones
- give examples and effects

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What they are

Endocrine disruptors are chemicals that interfere with the **hormone (endocrine) system** of animals and humans, even at very **low doses**.

■ How they act

They can **mimic** or **block** natural hormones, disrupting development, reproduction, and growth. Because hormones act in tiny amounts, small pollutant doses can have big effects.

■ Examples

- **Atrazine** (herbicide) — feminizes male frogs.
- **BPA** (in some plastics) — mimics estrogen.
- **DDT** and some industrial chemicals.

■ Effects

Reproductive problems, developmental defects, and altered sex ratios in wildlife (e.g. intersex fish) and possible human health effects.

2 Practice

Now apply the methods above.

2.1 What system do endocrine disruptors interfere with? [1]

2.2 Give one example of an endocrine disruptor. [1]

2.3 Why can very low doses have large effects? [1]

3 Exam-style questions

3.1 Endocrine disruptors are dangerous because they interfere with [1]

- **A** the skeleton
 - **B** hormones, even at low doses
 - **C** photosynthesis
 - **D** digestion only
-

3.2 A herbicide runs off into a pond and male frogs develop female traits.

(a) Explain how an endocrine disruptor could cause this. [2]

(b) State one effect on the frog population. [1]

3.3 Explain why endocrine disruptors can be harmful even at concentrations far below those of typical toxins. [2]

Solutions

2.1 The endocrine (hormone) system.

2.2 Any one: atrazine, BPA, DDT.

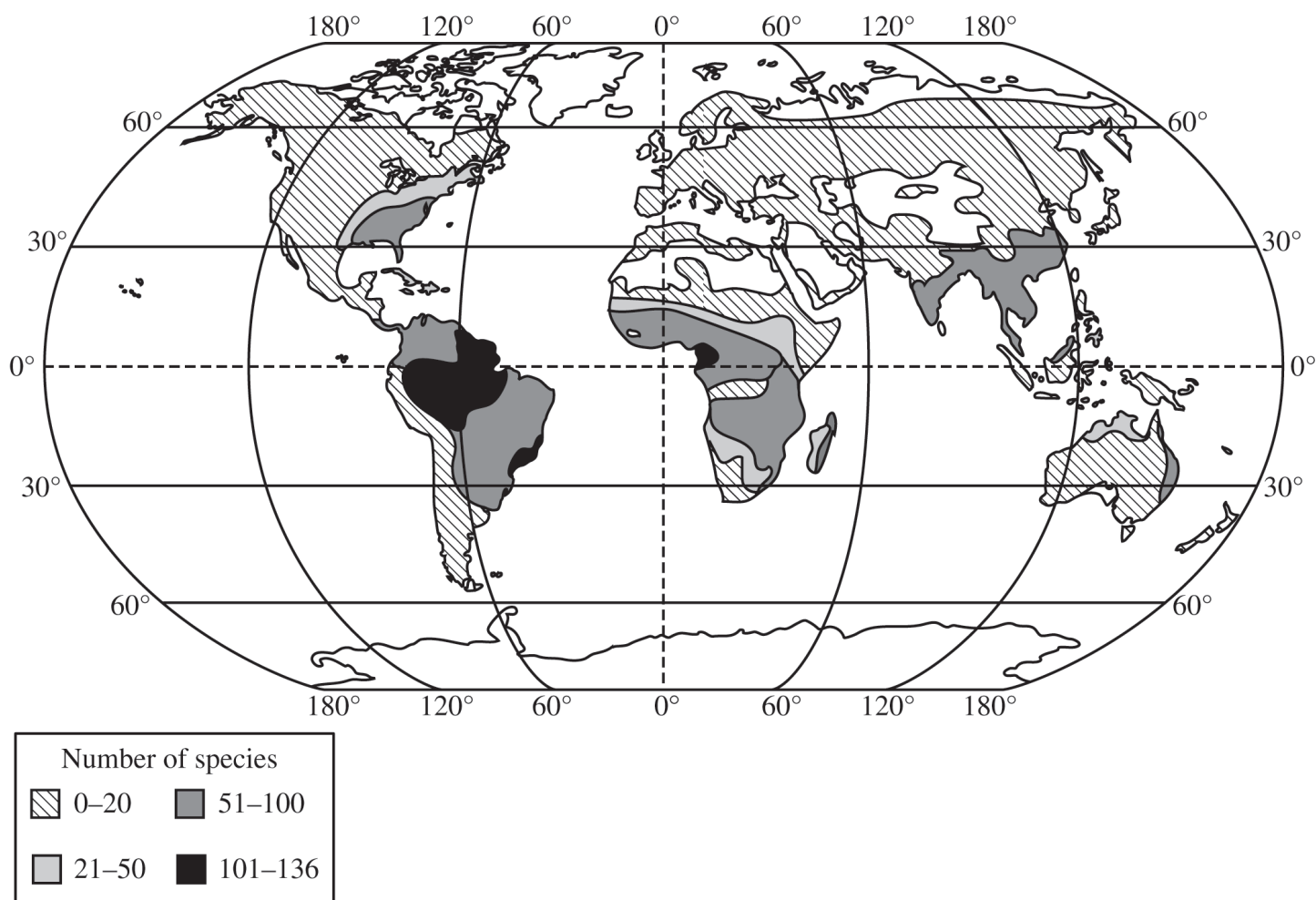
2.3 Hormones act in tiny amounts, so even small pollutant doses can disrupt them.

3.1 B — hormones, even at low doses.

3.2 (a) The chemical mimics a female hormone (estrogen), disrupting the frogs' hormone system and causing male frogs to develop female traits. (b) Reduced reproduction / skewed sex ratio, lowering population.

3.3 They mimic or block hormones, which naturally work at very low concentrations, so tiny amounts can strongly disrupt development and reproduction.

GLOBAL AMPHIBIAN SPECIES RICHNESS



2. Biodiversity around the world is changing as a result of anthropogenic influences.

(a) The map represents species richness of amphibians around the globe. Use the map to answer the following questions.

(i) **Identify** the latitudinal range with the greatest amphibian species richness.

(ii) **Identify** what biome this range most likely represents.

(iii) **Describe** one reason amphibian species richness would tend to be highest in this region.

(b) There are many environmental threats facing amphibians today, such as deforestation. **Describe** one possible anthropogenic reason for deforestation.

(c) Many factors influence biodiversity.

(i) **Explain** how the species richness of an ecosystem influences its response to environmental stressors.

(ii) **Explain** why amphibian biodiversity is declining globally, other than from deforestation.

(d) Currently, wildlife species are going extinct at an alarming rate. To combat this threat, governments around the world have enacted legislation and signed treaties to protect species threatened by extinction.

- (i) **Identify** one specific piece of legislation that has been designed to protect species threatened by extinction.
- (ii) **Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction.
- (e) A town is considering selling an undeveloped parcel of land along its border for residential developments. The square parcel of land consists of approximately 30% wetland and 70% pasture. The wetland runs through the middle of the property for its entire width and is home to three native frog species.
- (i) **Propose** a viable solution that will result in the protection of the native frog species while still allowing for maximum profit of the property development.
- (ii) **Justify** the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection.

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.

8.4 Human Impacts on Wetlands and Mangroves

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS wetlands 湿地 • mangroves 红树林

Objective

Build the skills to answer exam questions on **human impacts on wetlands and mangroves**.

You must be able to:

- state the **ecosystem services** of **wetlands** 湿地 and **mangroves** 红树林
- describe how human activity destroys them
- explain the consequences of their loss

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Why they matter

Wetlands and **mangroves** provide crucial services:

- **Water filtration** (removing pollutants).
- **Flood control** (absorbing storm surge and runoff).
- **Nurseries** for fish and wildlife (high biodiversity).
- **Carbon storage**.

■ How they are destroyed

Draining for farmland, **filling** for development, **pollution**, and clearing mangroves for **shrimp farms** or coastal building.

■ Consequences of loss

Losing them means **more flooding**, **worse water quality**, **lost fisheries**, and released carbon — plus greater storm damage to coasts.

■ A worked link

Clearing a mangrove for a shrimp farm removes the natural storm barrier, so the coast floods more badly during storms.

2 Practice

Now apply the methods above.

2.1 State two services provided by wetlands. [2]

2.2 Name one human activity that destroys mangroves. [1]

2.3 State one consequence of losing a wetland. [1]

3 Exam-style questions

3.1 Mangroves protect coastlines mainly by [1]

- **A** increasing storm surge
- **B** absorbing storm surge and reducing flooding
- **C** adding pollution
- **D** blocking sunlight

3.2 A coastal mangrove forest is cleared for development.

(a) State two ecosystem services that are lost. [2]

(b) Explain how this increases storm damage to the coast. [2]

3.3 Explain why draining a wetland can worsen local water pollution.

[2]

Solutions

2.1 Any two: water filtration, flood control, nurseries/habitat, carbon storage.

2.2 Any one: clearing for shrimp farms, coastal development, pollution.

2.3 Any one: more flooding, worse water quality, lost fisheries, released carbon.

3.1 B — absorbing storm surge and reducing flooding.

3.2 (a) Any two: storm/flood protection, nursery habitat, water filtration, carbon storage. (b) Without the mangroves' natural barrier, storm surge reaches the coast directly, causing more flooding and damage.

3.3 Wetlands filter pollutants from water; draining one removes that filtration, so more pollutants pass into rivers and groundwater.

1. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

- A. Based on the data in the graph, **identify** the number of Common Tern breeding pairs in 1995.
- B. Based on the data in the graph, **describe** the trend in the number of Common Tern breeding pairs from 1995 to 2008.
- C. A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. **Describe** one way that the data in the graph refute this hypothesis.
- D. **Explain** how climate change can lead to sea level rise.
- E. Wading birds are a group of large-bodied birds that inhabit coastal wetlands all over the world. Researchers monitored the number of wading bird species at four coastal locations experiencing rising sea levels over a 5-year period. The data are shown in the following table.

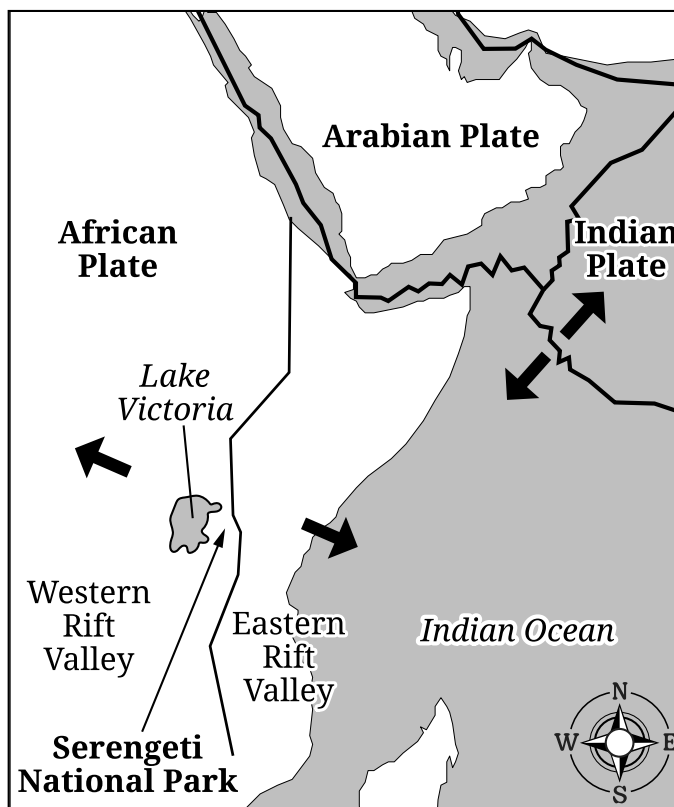
Sea Level Rise and Number of Wading Bird Species at Four Coastal Locations

Year	Increase in Sea Level (m)	Location A	Location B	Location C	Location D
1	0.05	1	5	3	4
2	0.08	2	4	3	6
3	0.10	6	7	5	5
4	0.12	5	7	7	7
5	0.15	7	8	9	8

- i. **Identify** a hypothesis that researchers are likely investigating in the wading bird study.
- ii. **Identify** the dependent variable in this study.
- F. One year after the completion of the study of wading bird species described in Part E, locations A and B experienced an increase in the concentration of PCBs, known to be a persistent organic pollutant, running off into the water.
If the researchers repeated their study, **explain** how this environmental change could affect the results of the study.
- G. **Describe** a regulating ecosystem service that can be provided by wetlands.
- H. Since 1990, there has been an increase in urbanization around the coastal wetlands that wading bird communities inhabit. Most of these bird species eat fish and locate prey visually while walking through shallow water. An increase in sediment was discovered in a wetland located near an urban area.
Explain how increased sediment might lead to a change in the size of the wading bird populations.
- I. **Describe** an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.

Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

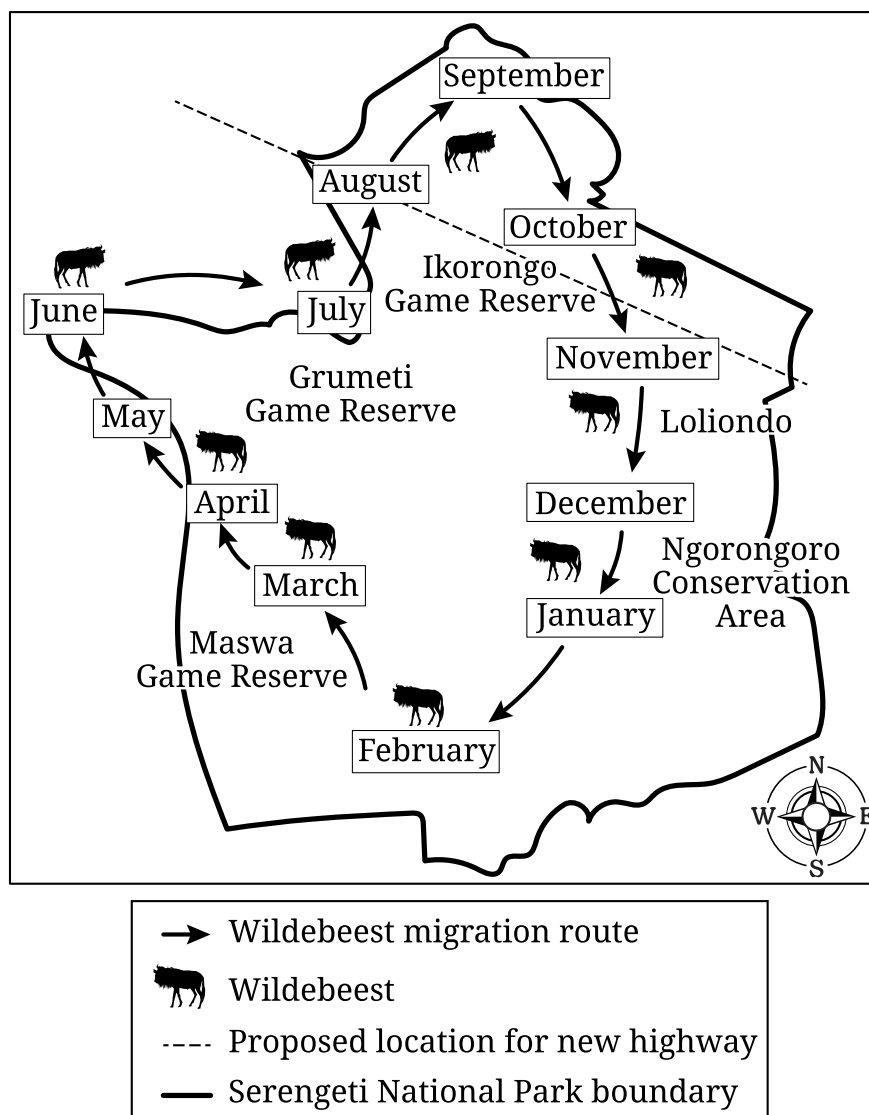
Figure 1. Tectonic Plate Movement near East Coast of Africa



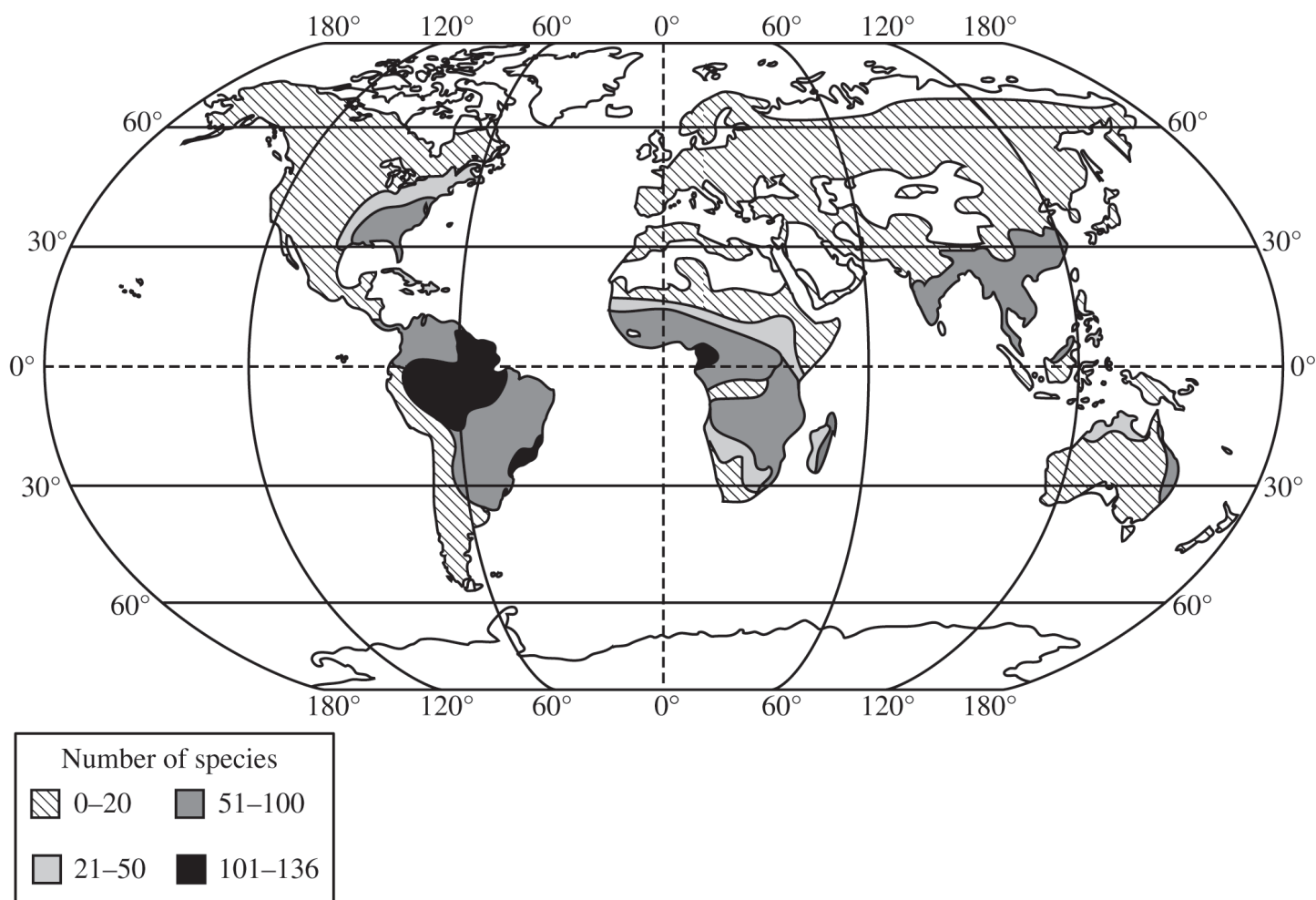
- ~ Plate boundaries
- East African Rift
- ➔ Direction of plate movement

Serengeti National Park contains a variety of tropical habitats but is dominated by wideopen lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate through the park in an annual cycle following the growth of new grass (Figure 2).

Figure 2. Annual Migration of Wildebeest in Serengeti National Park



GLOBAL AMPHIBIAN SPECIES RICHNESS



2. Biodiversity around the world is changing as a result of anthropogenic influences.

(a) The map represents species richness of amphibians around the globe. Use the map to answer the following questions.

(i) **Identify** the latitudinal range with the greatest amphibian species richness.

(ii) **Identify** what biome this range most likely represents.

(iii) **Describe** one reason amphibian species richness would tend to be highest in this region.

(b) There are many environmental threats facing amphibians today, such as deforestation. **Describe** one possible anthropogenic reason for deforestation.

(c) Many factors influence biodiversity.

(i) **Explain** how the species richness of an ecosystem influences its response to environmental stressors.

(ii) **Explain** why amphibian biodiversity is declining globally, other than from deforestation.

(d) Currently, wildlife species are going extinct at an alarming rate. To combat this threat, governments around the world have enacted legislation and signed treaties to protect species threatened by extinction.

- (i) **Identify** one specific piece of legislation that has been designed to protect species threatened by extinction.
- (ii) **Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction.
- (e) A town is considering selling an undeveloped parcel of land along its border for residential developments. The square parcel of land consists of approximately 30% wetland and 70% pasture. The wetland runs through the middle of the property for its entire width and is home to three native frog species.
- (i) **Propose** a viable solution that will result in the protection of the native frog species while still allowing for maximum profit of the property development.
- (ii) **Justify** the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection.

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.

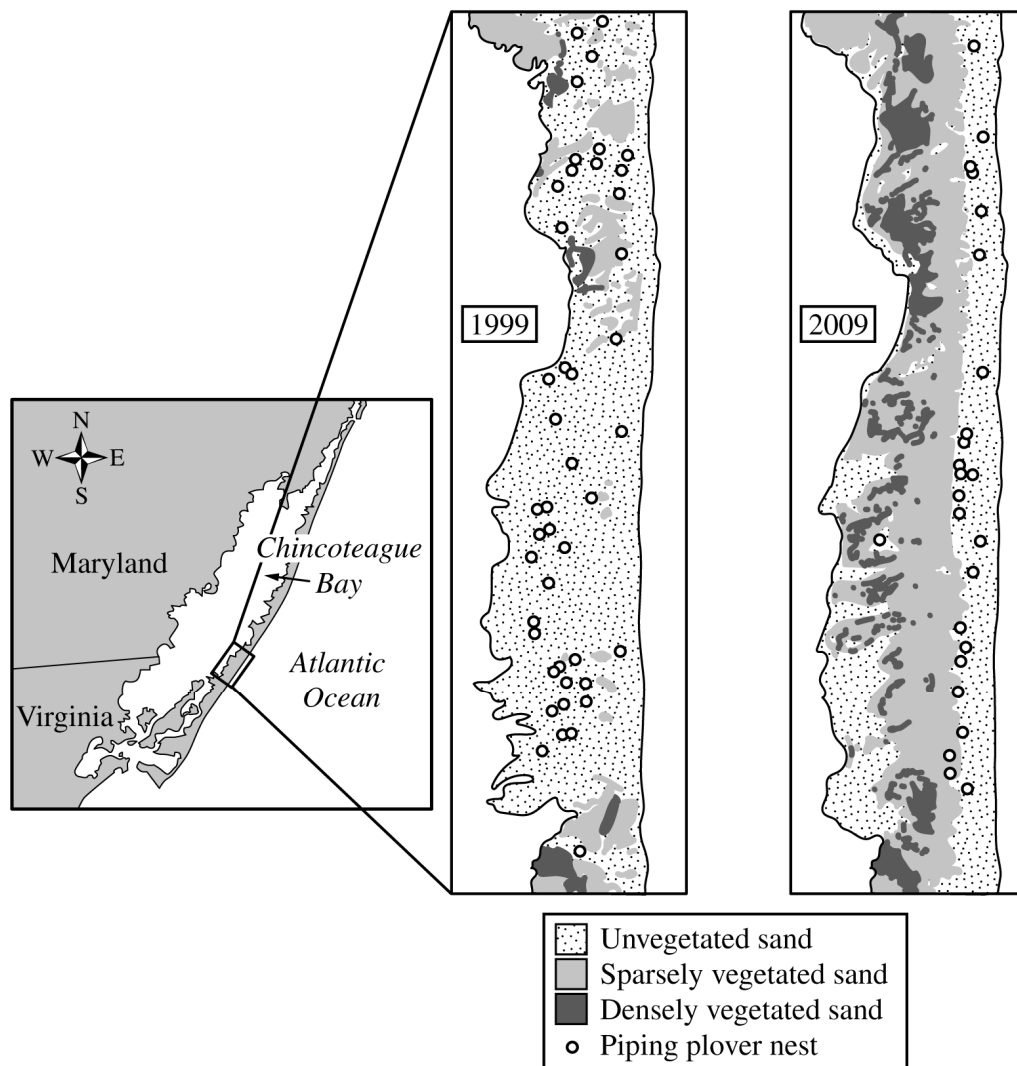
ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 minutes****4 Questions**

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. The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.

Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.

**SPRING PIPING PLOVER NESTING SITES
ON ASSATEAGUE ISLAND, VIRGINIA**



- (a) Use the maps provided to answer the following questions.
- (i) **Identify** the preferred nesting habitat for piping plovers.
 - (ii) **Describe** the change in the number of piping plover nests on Assateague Island between 1999 and 2009.
 - (iii) **Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.
- (b) Coastal species are affected by more than just natural events.
- (i) Special beach restrictions can help piping plovers during nesting season. **Describe** one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.
 - (ii) In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. **Explain** one way that these features help to preserve and protect the environment in coastal regions.
 - (iii) **Identify** one human action that directly threatens coastal habitats and **describe** one impact on species, other than the piping plover, that use the habitat.

Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

- (c) **Identify** one economic impact on coastal communities that has resulted from rising sea levels.
- (d) **Describe** TWO methods that may be used locally to protect coastal communities from rising sea levels.

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 Daily Times* and answer the questions that follow.

Fremont Daily Times

Scientists Discuss Threats from Plastic Pollution

In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake

them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

- (a) **Describe** TWO effects that ingesting microbeads has on aquatic organisms.
- (b) Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. **Describe** how nitrate levels can negatively affect water quality in some aquatic ecosystems.
- (c) While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants.
- (i) **Identify** one way large pieces of plastic are removed from wastewater during primary treatment.
 - (ii) Prior to discharge, wastewater is often disinfected. **Identify** one technique commonly used to disinfect wastewater.
 - (iii) Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. **Identify** one advantage and one disadvantage of this practice.
- (d) Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem.
- (i) **Provide** one reason why mangrove trees are being removed by humans.
 - (ii) **Identify** one ecosystem service provided by intact mangrove ecosystems.

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 article below and answer the questions that follow.

The Floridian Daily**May 21, 2013**

The small community located on the edge of the magnificent wetlands of Florida's Everglades was the site of a press conference today where Governor Gayle Moss announced that the restoration of the Everglades is successfully underway. She noted that the Everglades ecosystem has suffered threats to its water quality, water quantity, and habitats in recent decades. Moss noted that intensive urban and agricultural development in adjacent areas has diverted substantial amounts of

freshwater resources and impaired water quality. Governor Moss then emphasized that the preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state. She closed the press conference by saying, "The Everglades is a gem not only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

- (a) **Describe** how TWO human activities, other than those that result in anthropogenic climate change, have resulted in a decrease in the amount of freshwater flowing into the Everglades ecosystem.
- (b) In addition to water quantity problems, the Everglades is faced with a variety of water quality issues. For example, phosphorus concentrations in the Everglades have increased since the 1960s.
- (i) **Describe** how one specific human activity contributes to increased phosphorus levels in the Everglades.
 - (ii) **Explain** one way in which an increase in phosphorus levels can adversely affect the Everglades ecosystem.
 - (iii) **Describe** one step that could be taken to reduce phosphorus inputs from the activity you identified in part (i).
- (c) Climate change could have a variety of impacts on water quantity, water quality, and habitat. For EACH of these three factors, **identify and describe** one specific example of an impact on the Everglades likely to result from climate change.
- (d) The article states that Governor Moss believes that the "preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state."
- (i) **Describe** one way that restoring water quantity and water quality in the Everglades is expected to improve the structure and function of the ecosystem.
 - (ii) **Describe** one way that restoring the Everglades is expected to provide economic benefits to Florida.

8.5 Eutrophication

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS eutrophication 富营养化 • hypoxia 缺氧 • algal blooms 藻华
 • sewage treatment 污水处理

Objective

Build the skills to answer exam questions on **eutrophication**.

You must be able to:

- explain the **eutrophication** 富营养化 sequence
- link nutrients to algal blooms and oxygen loss
- describe **hypoxia** 缺氧 / dead zones

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The eutrophication sequence

1. **Excess nutrients** (nitrogen, phosphorus) enter water — usually from fertilizer runoff or sewage.
2. **Algal bloom** — algae grow explosively, covering the surface.
3. Algae **die** and **decompose**.
4. **Decomposers use up oxygen**, causing **hypoxia** (low oxygen).
5. Fish and other organisms **suffocate** — a **dead zone**.

■ The key cause

The nutrients that normally **limit** algal growth (especially phosphorus) become abundant, so algae grow out of control.

■ A worked link

Fertilizer runs off a farm into a lake → algal bloom → algae die → decomposers deplete oxygen → fish die.

■ Dead zones

Large **dead zones** (e.g. the Gulf of Mexico) form where big rivers deliver farm nutrients to the sea.

2 Practice

Now apply the methods above.

2.1 What nutrients cause eutrophication? [1]

2.2 What happens to oxygen levels during eutrophication? [1]

2.3 What is a dead zone? [1]

3 Exam-style questions

3.1 Fish die during eutrophication because decomposition of algae [1]

- **A** adds oxygen
 - **B** uses up the oxygen (causing hypoxia)
 - **C** removes nutrients
 - **D** cools the water
-

3.2 Fertilizer runs off farmland into a lake.

(a) Describe the sequence that leads to fish deaths. [3]

(b) State one way to prevent this. [1]

3.3 Explain why adding phosphorus in particular can trigger a bloom. [2]

Solutions

2.1 Nitrogen and phosphorus.

2.2 Oxygen is depleted (hypoxia).

2.3 An area of water with too little oxygen to support most life.

3.1 B — uses up the oxygen (causing hypoxia).

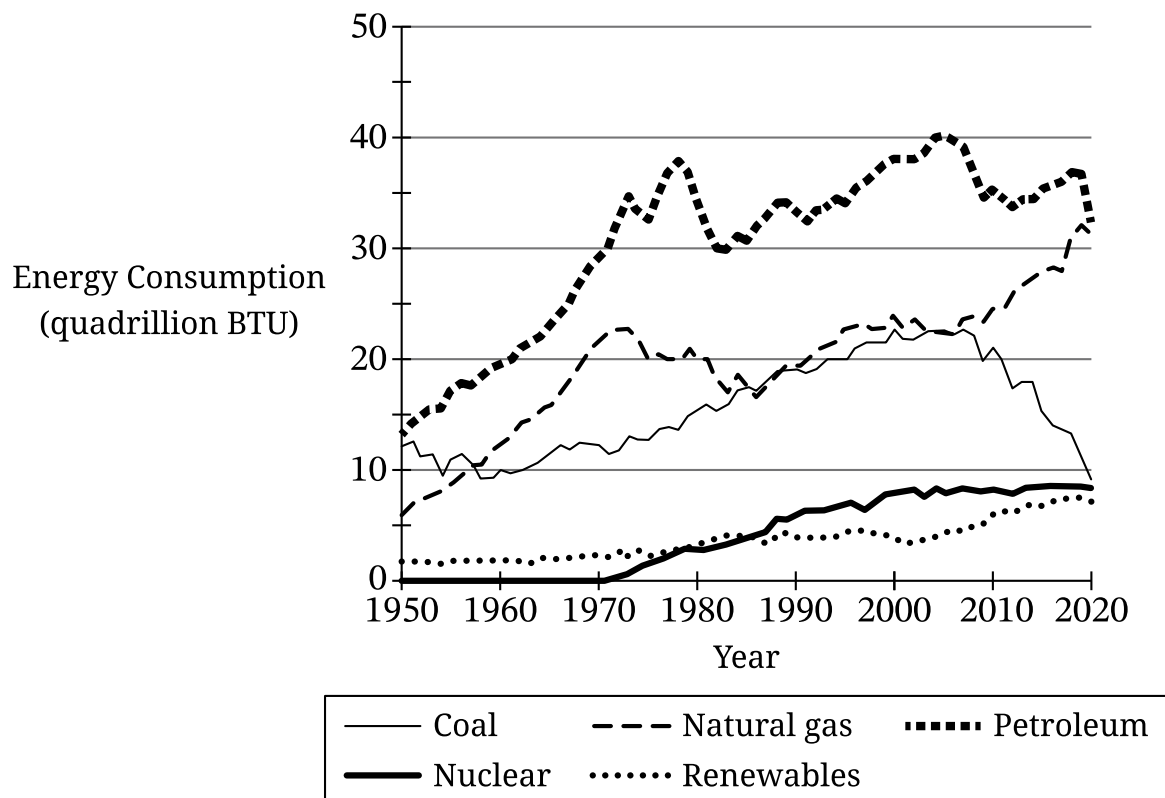
3.2 (a) Excess nutrients cause an algal bloom; the algae die and decompose; decomposers use up the oxygen, so fish suffocate. (b) Any one: buffer strips, reduced fertilizer, better sewage treatment.

3.3 Phosphorus is usually the limiting nutrient, so adding it removes the limit and lets algae grow explosively.

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950–2020



The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

Part A

Identify one renewable energy source that is used to generate electricity.

Part B

Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

Part C

Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

Part D

Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

Part E

Explain how fossil fuels are used to generate electricity.

Part F

In addition to fossil fuels, nuclear power can be used to generate electricity. **Identify** one negative impact associated with nuclear energy.

Part G

Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

Part H

Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

Part I

- i. **Propose** a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.
- ii. **Justify** the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

ENVIRONMENTAL SCIENCE

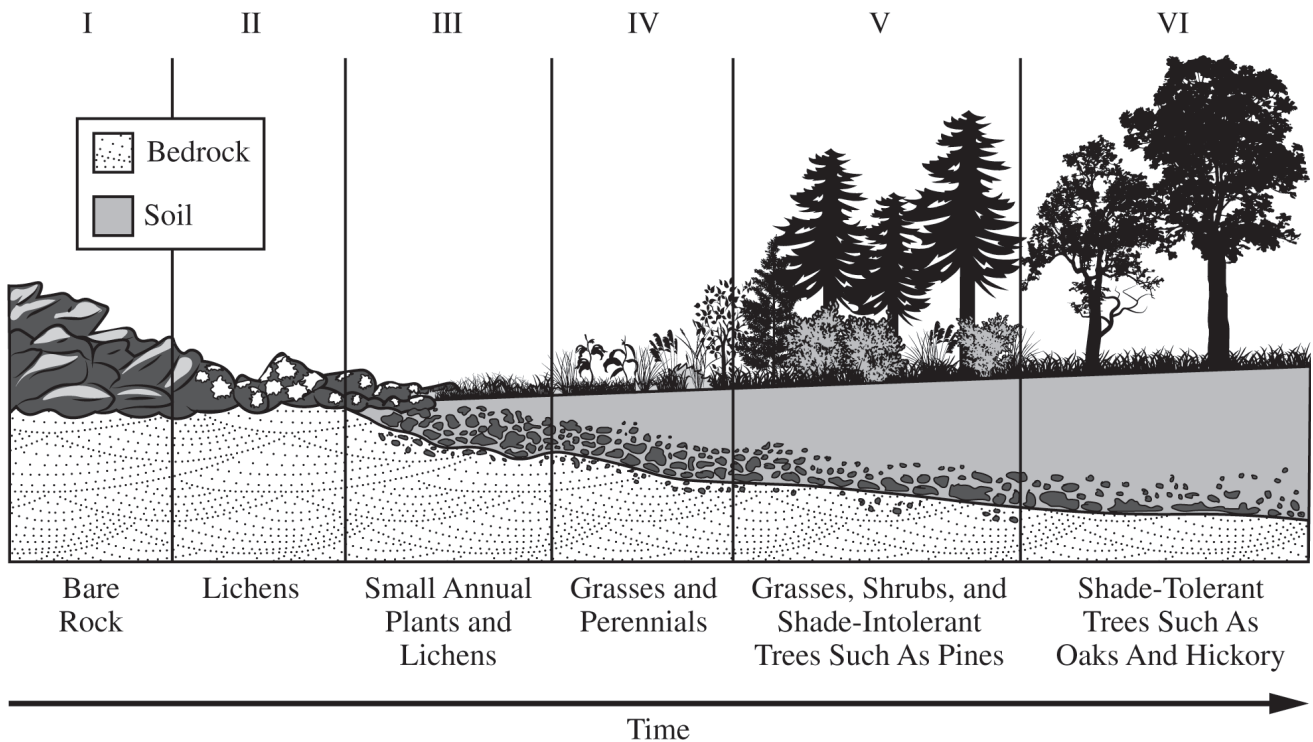
SECTION II

Time—1 hour and 10 minutes

3 Questions

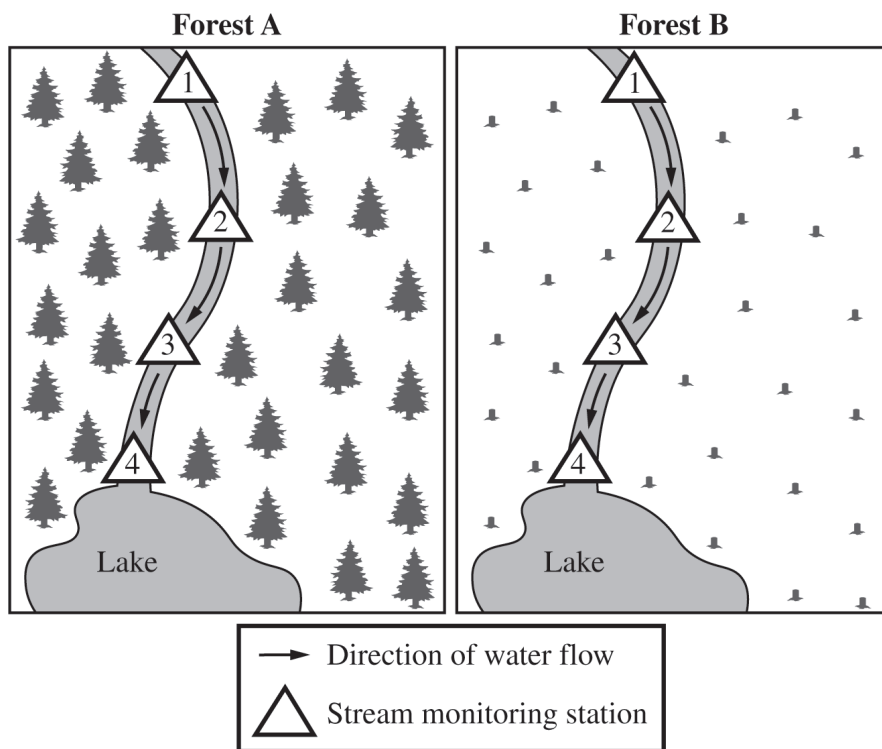
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1. The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.



- (a) **Identify** the ecological change over time illustrated in the diagram.
- (b) **Identify** the stage in which pioneer species first appear.
- (c) **Describe** how soil forms from stage II to stage III.
- (d) **Identify** a cultural ecosystem service that may be provided by a mature forest.

Researchers are interested in investigating the effect of the removal of trees on the water quality of nearby waterways. To conduct their experiment, the researchers locate two identical forest watersheds, both with a river running through them. Forest A is an intact forest and forest B is a clear-cut forest. Four stream monitoring stations are set up in each forest study area. Each station monitors a variety of water quality indicators, including water temperature, at various locations along the river. The experimental setup is shown in the following diagrams. The arrows shown in the rivers represent the direction of water flow. The triangles in the river show the location of the stream monitoring stations.



- (e) **Identify** a testable hypothesis being investigated by the researchers.
- (f) **Identify** the independent variable in the experiment.
- (g) **Describe** the purpose of forest A in the experiment.
- (h) **Explain** why the water temperature might change because of clear-cutting trees in forest B.

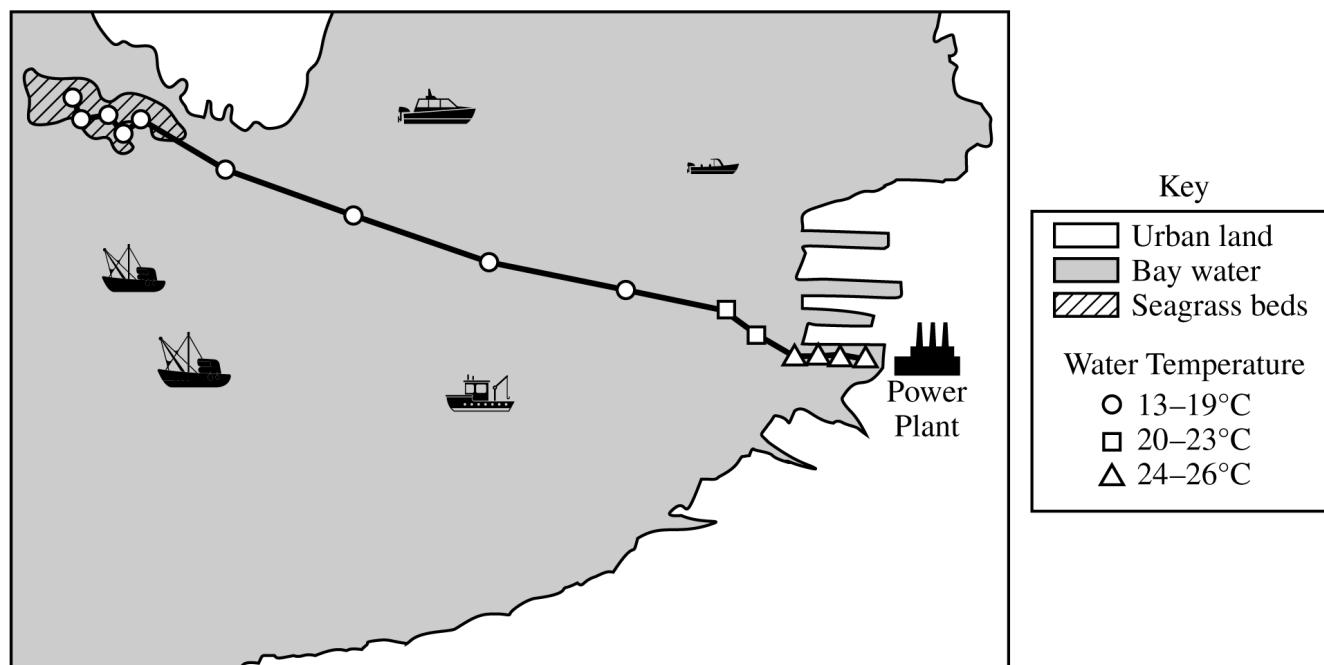
After the experiment was completed, land developers constructed a golf course in the clear-cut area of forest B. To prepare the land, developers removed any remaining stumps and newly grown trees and began planting and fertilizing new grass. The researchers are interested in the effect the golf course may have on the water quality of the river. To monitor the river in forest B, the researchers repeated the experiment once the golf course had been constructed.

- (i) **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B.
- (j) **Explain** how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course.

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2. The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below 20°C for extended periods of time.

Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period



- (a) Based on the information in the diagram, **identify** the temperature range of the water through which the majority of the adult manatee's daily movement occurs.
- (b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, **identify** a characteristic of the power plant waste water that would attract the manatees.
- (c) Based on the information in the diagram, **describe** a potential negative impact of the waste water released by the power plant on other aquatic species.
- (d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.
- (i) **Describe** a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.
 - (ii) **Describe** the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(i) **Propose** a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(ii) **Justify** the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

(f) **Describe** how summertime weather conditions can increase the frequency of photochemical smog.

(g) **Identify** one ecological problem that results from exposure to photochemical smog.

A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

(h) **Describe** a potential disadvantage of using hydrogen fuel cells to power automobiles.

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ENVIRONMENTAL SCIENCE

SECTION II

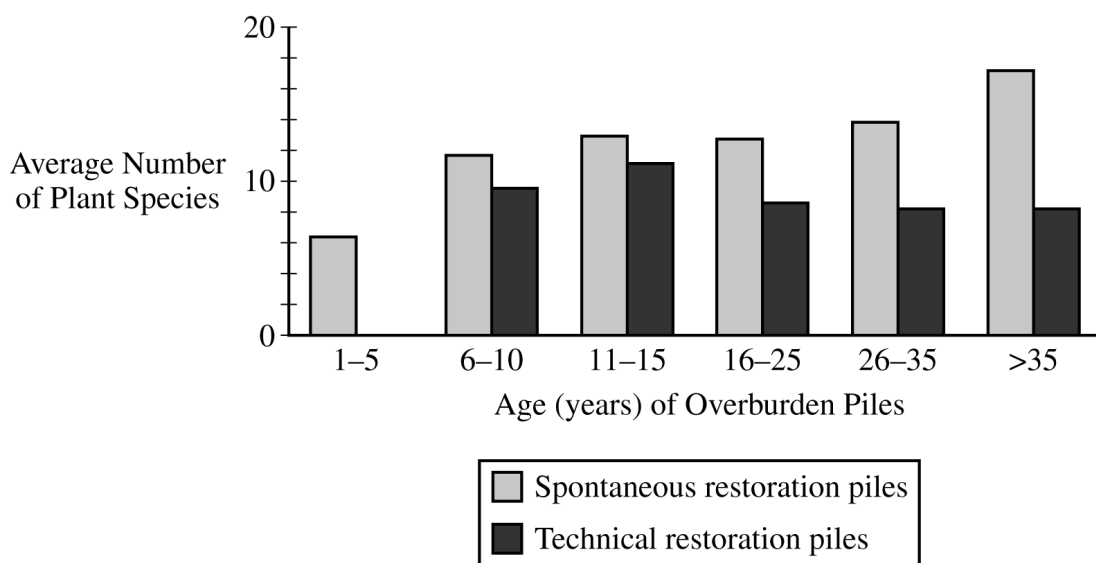
Time—1 hour and 10 minutes

3 Questions

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1. Two restoration methods designed to reclaim the overburden piles removed from open pit coal mines in temperate forests of eastern Europe were studied over several years. The first method was spontaneous restoration, where the soil and rock were dumped in noncompacted, random piles and not replanted with vegetation. The second method was technical restoration, where the land was leveled by heavy machinery, organic material was added, and eight plant species were added. Technical restoration started 5 years after the piles were formed, so no bar is included in the 1–5 year range in the graph.

Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time



- (a) Based on the data in the graph, **identify** the average number of species found in technically restored piles 16–25 years after restoration started.
- (b) Based on the data in the graph, **describe** the relationship between the average number of species and the age of the spontaneous restoration piles.

Scientists hypothesized that after 35 years, the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.

- (c) Using the data in the graph, **make a claim** that supports or refutes the hypothesis that the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.
- (d) **Describe** a characteristic of a plant species that would have been present in the spontaneous restoration piles from years 1 to 5.
- (e) **Explain** how the return of plant life would have been altered in the spontaneous piles if the mining had taken place in the tundra rather than in temperate forests.

Limiting runoff on disturbed land improves soil and water quality. To model water runoff, students set up three large plastic trays and filled each tray with loam soil to 1 centimeter below the edge. Loam soil is a balance of sand, silt, and clay soil. One tray was seeded with wheatgrass and grown for 30 days, one tray was covered with small wood chips, and one tray was soil only. Five hundred milliliters of water was sprinkled evenly onto the soil surface of each tray. All three trays were placed on a slight slope, and water that ran off the surface was collected. The results are shown in the following table.

Tray	Water Collected (mL)	Water Appearance
Wheatgrass grown in soil; no small wood chips	190	Clear
Small wood chips covered soil; no wheatgrass	300	Transparent; light brown
Soil only; no wheatgrass or small wood chips	360	Cloudy; dark brown

- (f) **Identify** the scientific question for the investigation.
- (g) **Identify** a dependent variable in the experiment.
- (h) **Explain** how the results of the experiment would likely have been altered if the soil had contained a higher percentage of sand, which has the largest particle size of the components of loam.

Runoff from mining waste can also affect water quality.

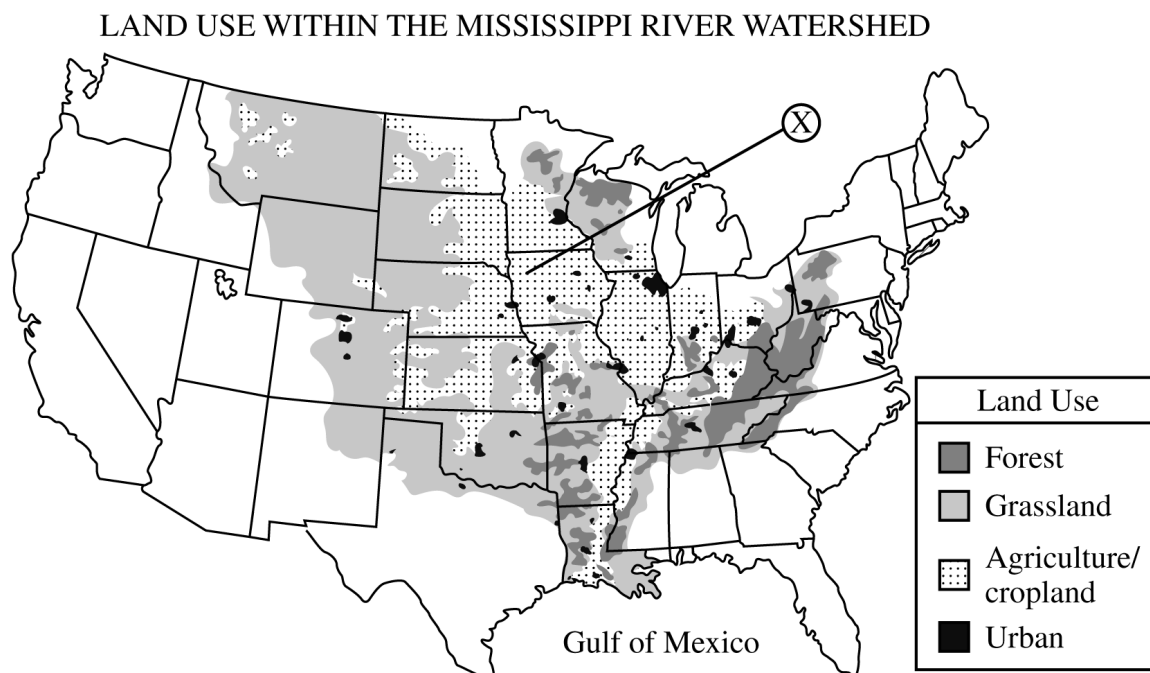
- (i) **Describe** one ecological impact that could result from the drainage from mine waste into nearby waterways.
- (j) **Describe** one strategy to reduce the drainage from mine waste into waterways downstream from mines.

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.

ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 10 minutes****3 Questions**

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. The dead zone in the Gulf of Mexico occurs every summer when winter snow melts and spring rain flows into the Mississippi River. Recent studies have shown that both the total area covered by algae and the depth of the algal mass in the dead zone are increasing.



- (a) Various land use practices can have different effects on the waters that surround a dead zone.
- (i) **Identify** the land use that covers the least amount of area in the Mississippi River watershed, based on the diagram.
 - (ii) **Describe** one way that the land use practice at location X in the diagram could contribute to the dead zone in the Gulf of Mexico.
 - (iii) **Describe** one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico.

- (b) The dead zone in the Gulf of Mexico has both economic and environmental effects for coastal communities.
- (i) **Describe** how a dead zone affects marine organisms living in the Gulf of Mexico.
 - (ii) **Describe** one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone.
 - (iii) **Describe** one factor that causes the area of the dead zone in the Gulf of Mexico to increase in the summer months.
- (c) Researchers want to examine the effect of riparian vegetation buffers on water quality in streams in agricultural areas. Researchers will measure the water nutrient concentrations over the course of one year. The study sites are located 100 meters downstream from areas either with or without riparian vegetation buffers.
- (i) **Identify** a testable hypothesis for the study.
 - (ii) **Describe** a control that the researchers could use in the study.
 - (iii) **Identify** one water quality test, other than measuring nitrates or phosphates, that the researchers could use to evaluate how riparian vegetation buffers affect water quality.
 - (iv) During the investigation, researchers discovered that some of the land next to one of the streams with a riparian vegetation buffer is going to be converted from cornfields into a large-scale concentrated animal feeding operation. **Explain** one way that this change in land use could alter the results of the study.

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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 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 Daily Times* and answer the questions that follow.

Fremont Daily Times

Scientists Discuss Threats from Plastic Pollution

In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake

them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

- (a) **Describe** TWO effects that ingesting microbeads has on aquatic organisms.
- (b) Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. **Describe** how nitrate levels can negatively affect water quality in some aquatic ecosystems.
- (c) While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants.
- (i) **Identify** one way large pieces of plastic are removed from wastewater during primary treatment.
 - (ii) Prior to discharge, wastewater is often disinfected. **Identify** one technique commonly used to disinfect wastewater.
 - (iii) Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. **Identify** one advantage and one disadvantage of this practice.
- (d) Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem.
- (i) **Provide** one reason why mangrove trees are being removed by humans.
 - (ii) **Identify** one ecosystem service provided by intact mangrove ecosystems.

ENVIRONMENTAL SCIENCE**SECTION II****Time—90 minutes****4 Questions**

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1. Read the article below and answer the questions that follow.

The Floridian Daily**May 21, 2013**

The small community located on the edge of the magnificent wetlands of Florida's Everglades was the site of a press conference today where Governor Gayle Moss announced that the restoration of the Everglades is successfully underway. She noted that the Everglades ecosystem has suffered threats to its water quality, water quantity, and habitats in recent decades. Moss noted that intensive urban and agricultural development in adjacent areas has diverted substantial amounts of

freshwater resources and impaired water quality. Governor Moss then emphasized that the preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state. She closed the press conference by saying, "The Everglades is a gem not only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

- (a) **Describe** how TWO human activities, other than those that result in anthropogenic climate change, have resulted in a decrease in the amount of freshwater flowing into the Everglades ecosystem.
- (b) In addition to water quantity problems, the Everglades is faced with a variety of water quality issues. For example, phosphorus concentrations in the Everglades have increased since the 1960s.
- (i) **Describe** how one specific human activity contributes to increased phosphorus levels in the Everglades.
 - (ii) **Explain** one way in which an increase in phosphorus levels can adversely affect the Everglades ecosystem.
 - (iii) **Describe** one step that could be taken to reduce phosphorus inputs from the activity you identified in part (i).
- (c) Climate change could have a variety of impacts on water quantity, water quality, and habitat. For EACH of these three factors, **identify and describe** one specific example of an impact on the Everglades likely to result from climate change.
- (d) The article states that Governor Moss believes that the "preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state."
- (i) **Describe** one way that restoring water quantity and water quality in the Everglades is expected to improve the structure and function of the ecosystem.
 - (ii) **Describe** one way that restoring the Everglades is expected to provide economic benefits to Florida.

8.6 Thermal Pollution

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS dissolved oxygen 溶解氧 • thermal pollution 热污染

Objective

Build the skills to answer exam questions on **thermal pollution**.

You must be able to:

- define **thermal pollution** 热污染
- explain how warm water lowers **dissolved oxygen** 溶解氧
- give sources and solutions

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What it is

Thermal pollution is a harmful rise (or sometimes drop) in water temperature caused by human activity — most often **warm water discharged** from power plants used for cooling.

■ Warm water holds less oxygen

Warmer water holds less dissolved oxygen. So thermal pollution lowers oxygen just when fish (whose metabolism speeds up in warm water) need more — stressing or killing aquatic life.

■ Sources

Power plants and factories using water for **cooling**; also runoff from hot pavement.

■ Solutions

Cooling towers or **cooling ponds** let the water cool before release; releasing water gradually reduces the shock.

■ A worked link

A power plant discharges hot water into a river → the river warms → dissolved oxygen falls → fish are stressed or die.

2 Practice

Now apply the methods above.

2.1 What is thermal pollution? [1]

2.2 How does warm water affect dissolved oxygen? [1]

2.3 Name one source of thermal pollution. [1]

3 Exam-style questions

3.1 Warm water harms aquatic life mainly because it [1]

- **A** holds more oxygen
 - **B** holds less dissolved oxygen
 - **C** adds nutrients
 - **D** freezes
-

3.2 A power plant releases hot cooling water into a lake.

(a) Explain how this can kill fish. [2]

(b) Suggest one way to reduce the thermal pollution. [1]

3.3 Explain why the effect is worse in summer. [2]

Solutions

2.1 A harmful change (usually rise) in water temperature from human activity.

2.2 Warm water holds less dissolved oxygen.

2.3 Any one: power plant/factory cooling discharge, hot pavement runoff.

3.1 B — holds less dissolved oxygen.

3.2 (a) The hot water warms the lake, lowering dissolved oxygen while raising fish metabolism (higher oxygen demand), so fish suffocate. (b) Use a cooling tower/pond before releasing the water.

3.3 In summer the water is already warm with low oxygen, so extra heat pushes oxygen even lower, more easily killing fish.

3. Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

- (a) **Identify** a fuel used in a nuclear power plant.
- (b) **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.
- (c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work.

Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

- (d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

- (e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.
- (f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.
- (g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

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.

STOP

END OF EXAM



ENVIRONMENTAL SCIENCE

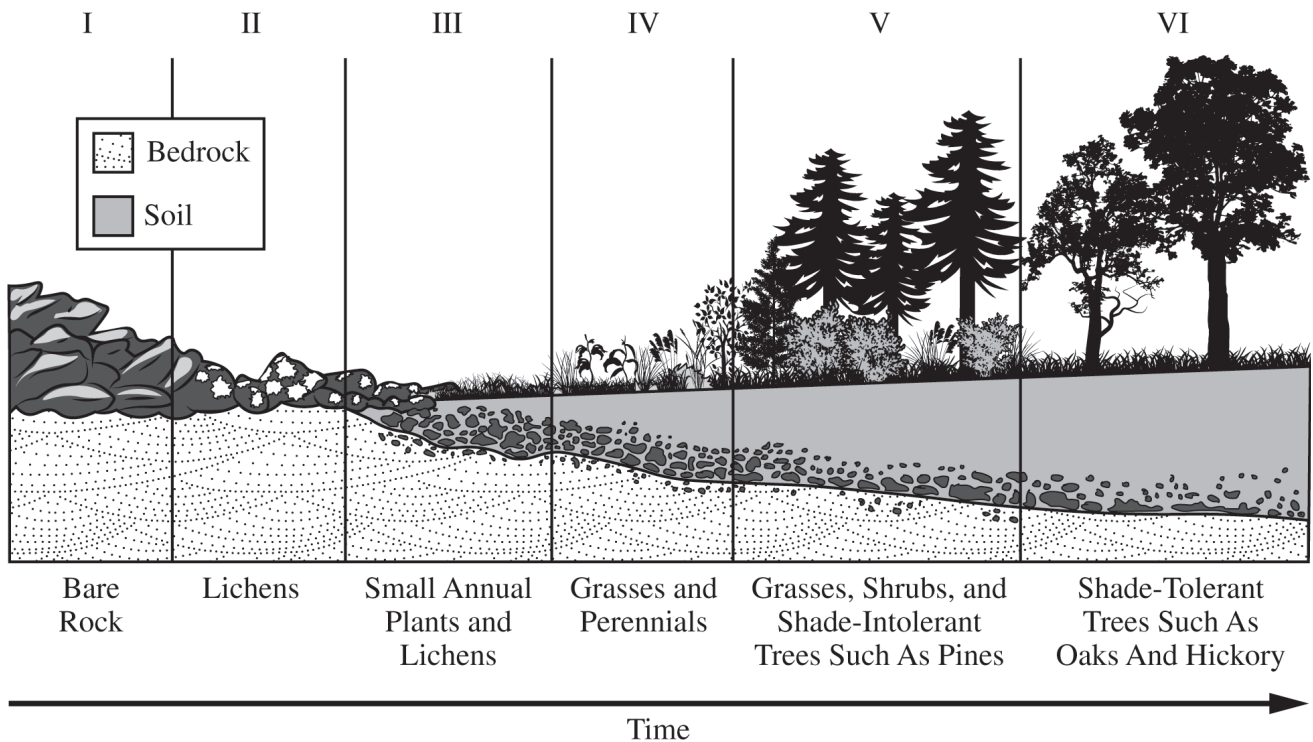
SECTION II

Time—1 hour and 10 minutes

3 Questions

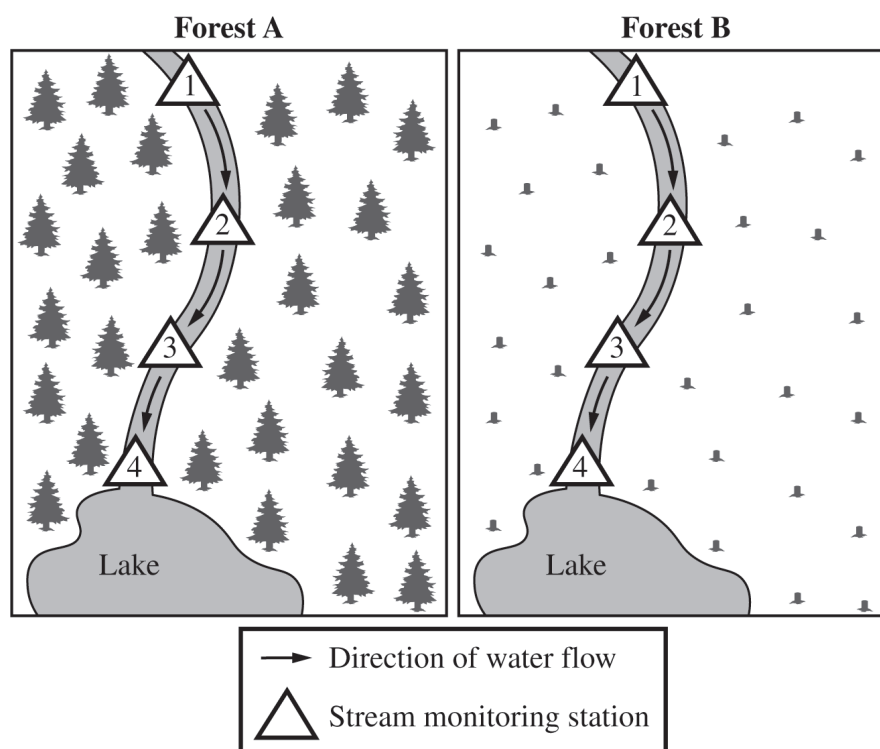
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1. The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.



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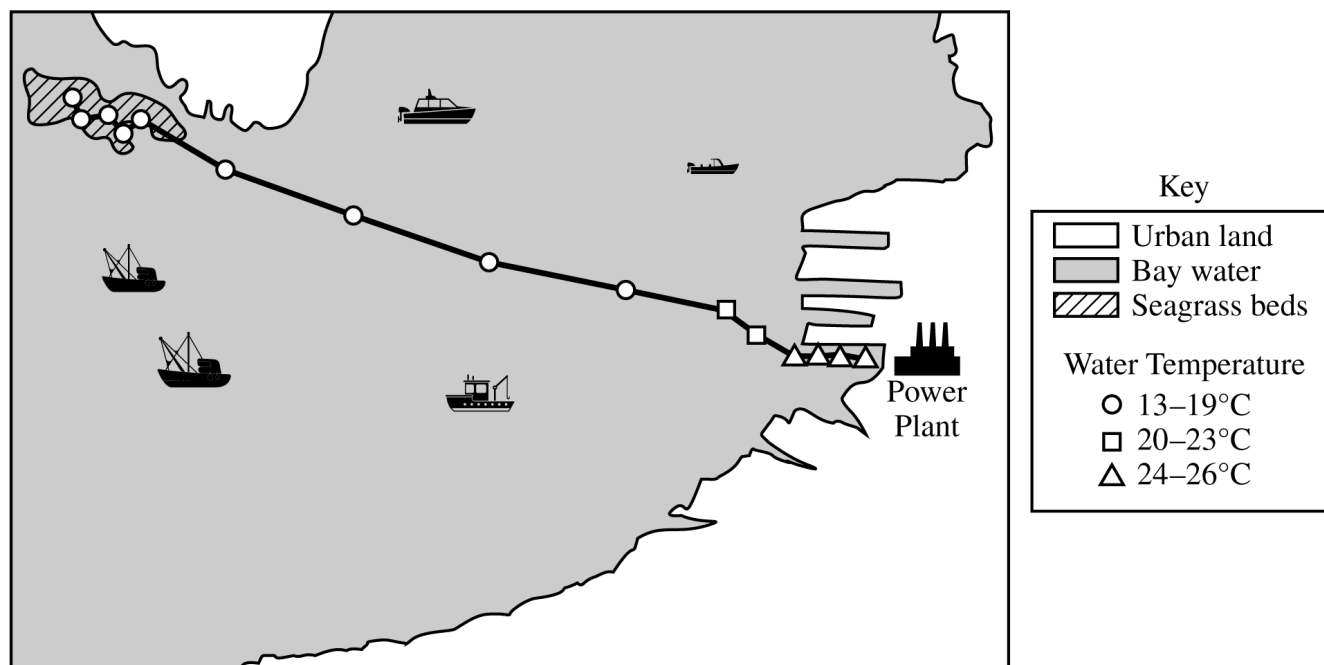
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- (i) **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B.
- (j) **Explain** how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course.

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2. The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below 20°C for extended periods of time.

Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period



- (a) Based on the information in the diagram, **identify** the temperature range of the water through which the majority of the adult manatee's daily movement occurs.
- (b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, **identify** a characteristic of the power plant waste water that would attract the manatees.
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- Describe** a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.
 - Describe** the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

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(ii) **Justify** the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

(f) **Describe** how summertime weather conditions can increase the frequency of photochemical smog.

(g) **Identify** one ecological problem that results from exposure to photochemical smog.

A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

(h) **Describe** a potential disadvantage of using hydrogen fuel cells to power automobiles.

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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 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 article below and answer the questions that follow.

The Fremont Plaindealer**May 1, 2013**

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that “nuclear power plants produce no dangerous solid waste” and “using nuclear power avoids the release of

greenhouse gases.”

Councilperson Chinh Serach said that Dr. Kull’s remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

- (a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.
- (i) “Nuclear power plants produce no dangerous solid waste.”
 - (ii) “Using nuclear power avoids the release of greenhouse gases.”
- (b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).
- (c) Suppose that the nuclear power plant is constructed on the Fremont River site.
- (i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant’s normal daily operation.
 - (ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).
 - (iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).
- (d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.
- (e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

8.7 Persistent Organic Pollutants (POPs)

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS persistent organic pollutants 持久性有机污染物 • biomagnification 生物放大

Objective

Build the skills to answer exam questions on **persistent organic pollutants (POPs)**.

You must be able to:

- describe **POPs** 持久性有机污染物 (persistent, bioaccumulate, travel far)
- give examples (DDT, PCBs)
- explain why they are dangerous

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What POPs are

Persistent organic pollutants (POPs) are synthetic chemicals that:

- **persist** (do not break down for a long time),
- **bioaccumulate** (build up in fatty tissue),
- **travel long distances** (even to the Arctic), and
- are **toxic** (cause cancer, reproductive harm).

■ Examples

DDT (pesticide), **PCBs** (industrial), dioxins. Many are now banned or restricted (e.g. by the Stockholm Convention).

■ Why they are dangerous

Because they persist and bioaccumulate, they **build up in food chains** (biomagnification) and reach harmful levels in top predators and humans, far from where they were used.

■ A worked link

DDT sprayed decades ago still persists and accumulates in birds of prey, thinning their eggshells — an effect that led to its ban.

2 Practice

Now apply the methods above.

2.1 State two properties of POPs. [2]

2.2 Give one example of a POP. [1]

2.3 Why can POPs reach remote places like the Arctic? [1]

3 Exam-style questions

3.1 POPs are especially dangerous because they [1]

- **A** break down instantly
 - **B** persist and bioaccumulate in food chains
 - **C** stay only where used
 - **D** are harmless
-

3.2 DDT was widely used decades ago and is still found in wildlife.

(a) Explain why it is still present. [2]

(b) State one harmful effect on wildlife. [1]

3.3 Explain why POPs reach their highest concentrations in top predators. [2]

Solutions

2.1 Any two: persistent, bioaccumulate, travel long distances, toxic.

2.2 Any one: DDT, PCBs, dioxins.

2.3 They persist and are carried long distances by air and water.

3.1 B — persist and bioaccumulate in food chains.

3.2 (a) DDT is persistent — it does not break down quickly, so it remains in the environment and in animals' tissues for decades. (b) Eggshell thinning in birds of prey (or reproductive harm).

3.3 POPs bioaccumulate and biomagnify — they concentrate up each trophic level — so top predators, which eat many contaminated prey, accumulate the highest levels.

1. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

- A. Based on the data in the graph, **identify** the number of Common Tern breeding pairs in 1995.
- B. Based on the data in the graph, **describe** the trend in the number of Common Tern breeding pairs from 1995 to 2008.
- C. A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. **Describe** one way that the data in the graph refute this hypothesis.
- D. **Explain** how climate change can lead to sea level rise.
- E. Wading birds are a group of large-bodied birds that inhabit coastal wetlands all over the world. Researchers monitored the number of wading bird species at four coastal locations experiencing rising sea levels over a 5-year period. The data are shown in the following table.

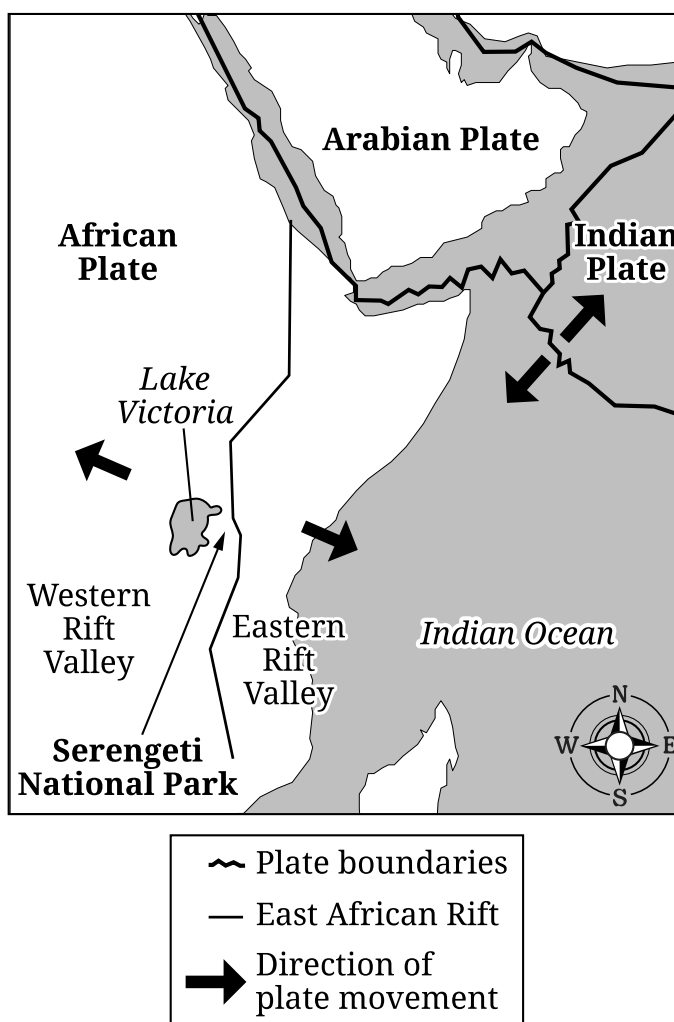
Sea Level Rise and Number of Wading Bird Species at Four Coastal Locations

Year	Increase in Sea Level (m)	Location A	Location B	Location C	Location D
1	0.05	1	5	3	4
2	0.08	2	4	3	6
3	0.10	6	7	5	5
4	0.12	5	7	7	7
5	0.15	7	8	9	8

- i. **Identify** a hypothesis that researchers are likely investigating in the wading bird study.
- ii. **Identify** the dependent variable in this study.
- F. One year after the completion of the study of wading bird species described in Part E, locations A and B experienced an increase in the concentration of PCBs, known to be a persistent organic pollutant, running off into the water.
If the researchers repeated their study, **explain** how this environmental change could affect the results of the study.
- G. **Describe** a regulating ecosystem service that can be provided by wetlands.
- H. Since 1990, there has been an increase in urbanization around the coastal wetlands that wading bird communities inhabit. Most of these bird species eat fish and locate prey visually while walking through shallow water. An increase in sediment was discovered in a wetland located near an urban area.
Explain how increased sediment might lead to a change in the size of the wading bird populations.
- I. **Describe** an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.

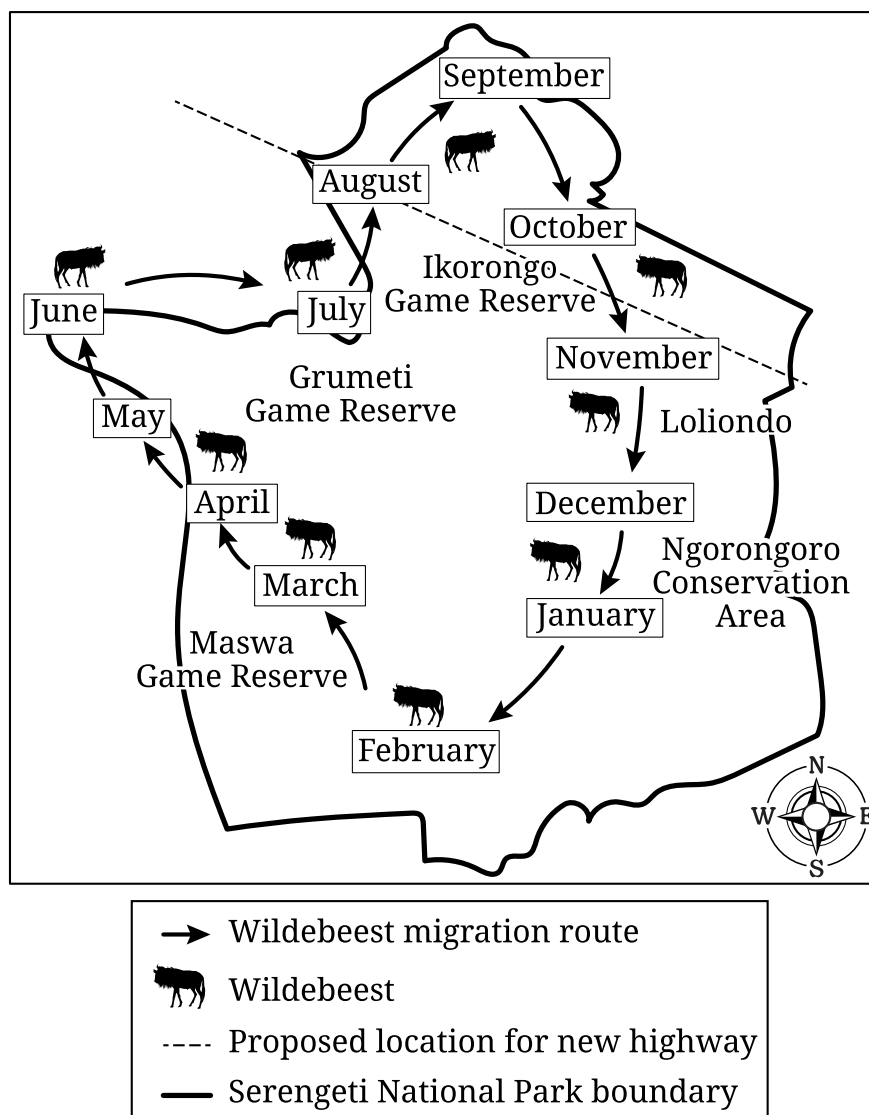
Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa



Serengeti National Park contains a variety of tropical habitats but is dominated by wideopen lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate through the park in an annual cycle following the growth of new grass (Figure 2).

Figure 2. Annual Migration of Wildebeest in Serengeti National Park



ENVIRONMENTAL SCIENCE

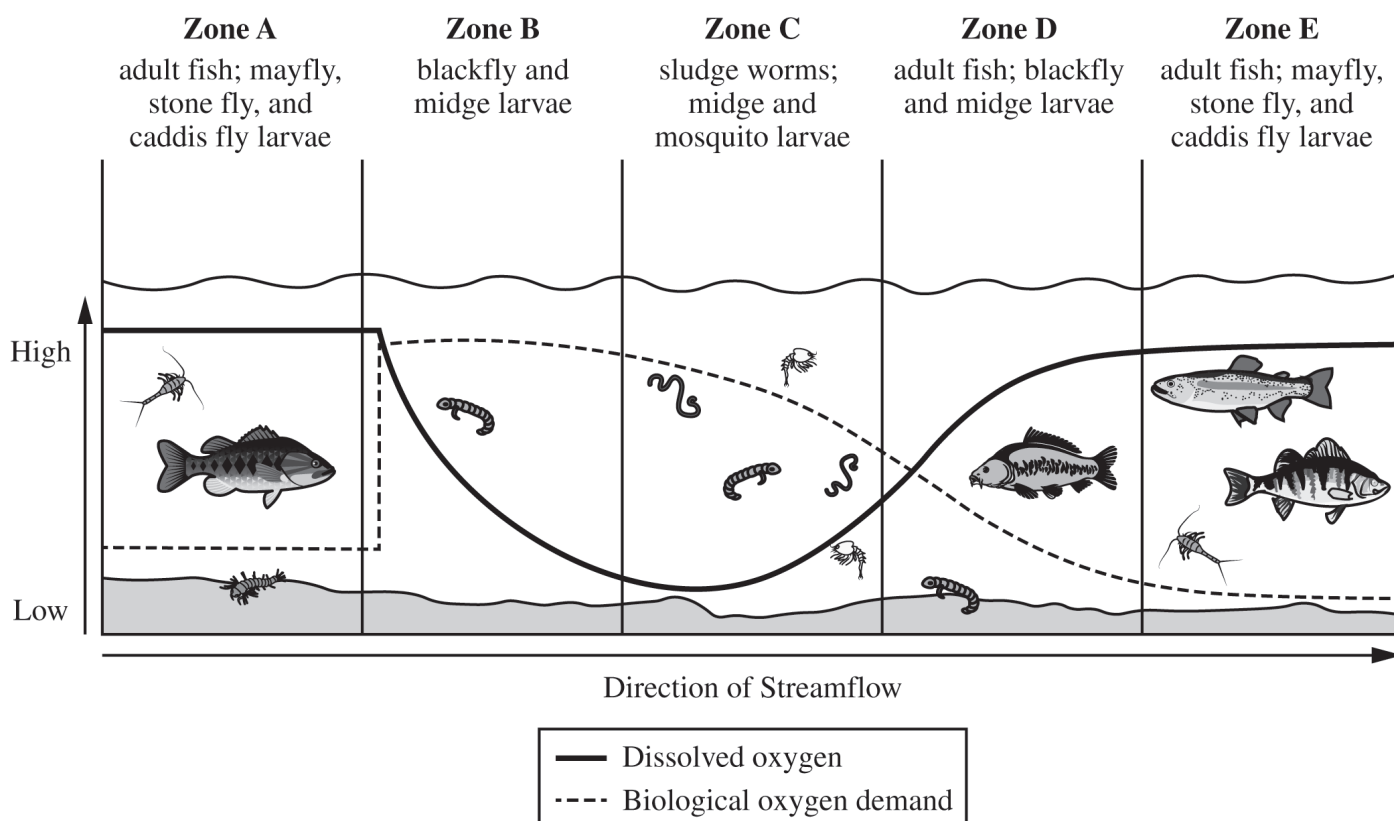
SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen..
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.
- (c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

- (d) **Identify** the dependent variable in the researchers' investigation.
- (e) **Identify** a testable hypothesis for the researchers' investigation.
- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

- (g) **Explain** how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.
- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

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.

ENVIRONMENTAL SCIENCE

SECTION II

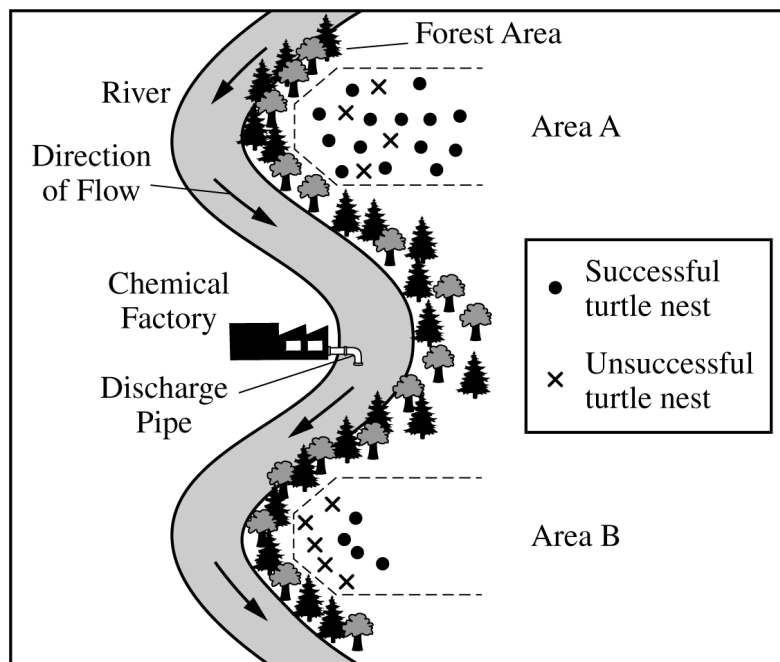
Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.

DISTRIBUTION OF TURTLE NESTS ALONG RIVER



- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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.

8.8 Bioaccumulation and Biomagnification

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS biomagnification 生物放大 • bioaccumulation 生物累积

Objective

Build the skills to answer exam questions on **bioaccumulation** and **biomagnification**.

You must be able to:

- distinguish **bioaccumulation** 生物累积 from **biomagnification** 生物放大
- explain why top predators have the highest levels
- give examples (mercury, DDT)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Bioaccumulation

Bioaccumulation is the build-up of a persistent toxin **within one organism** over its lifetime, because it is taken in faster than it is removed (stored in fat).

■ Biomagnification

Biomagnification is the **increase in concentration up the food chain**. Each predator eats many contaminated prey, so the toxin concentrates at each higher trophic level.

■ Top predators worst affected

Because levels multiply at each step, **top predators** (and humans) end up with the **highest** concentrations — sometimes millions of times the water level.

■ A worked example

Mercury enters water, is taken up by plankton (bioaccumulation), then concentrates through small fish → big fish → humans (biomagnification), which is why large predatory fish (tuna, shark) carry high mercury.

2 Practice

Now apply the methods above.

2.1 Define bioaccumulation. [1]

2.2 Define biomagnification. [1]

2.3 Which organisms have the highest toxin levels? [1]

3 Exam-style questions

3.1 Biomagnification describes toxins that [1]

- **A** decrease up the food chain
 - **B** increase in concentration up the food chain
 - **C** stay constant
 - **D** disappear
-

3.2 Mercury is released into a lake.

(a) Explain how it becomes concentrated in large fish. [3]

(b) State why humans are advised to limit eating large predatory fish. [1]

3.3 Explain why a toxin must be persistent to biomagnify. [2]

Solutions

2.1 Build-up of a toxin within one organism over its life.

2.2 Increase in a toxin's concentration up the food chain.

2.3 Top predators.

3.1 B — increase in concentration up the food chain.

3.2 (a) Mercury is taken up by plankton and accumulates; small fish eat many plankton, big fish eat many small fish, so it concentrates (biomagnifies) at each level, reaching high levels in large fish. (b) Large predatory fish have the highest mercury levels, which are harmful to health.

3.3 If the toxin broke down quickly it would not persist long enough to accumulate and pass up the chain; persistence lets it build up at each level.

ENVIRONMENTAL SCIENCE

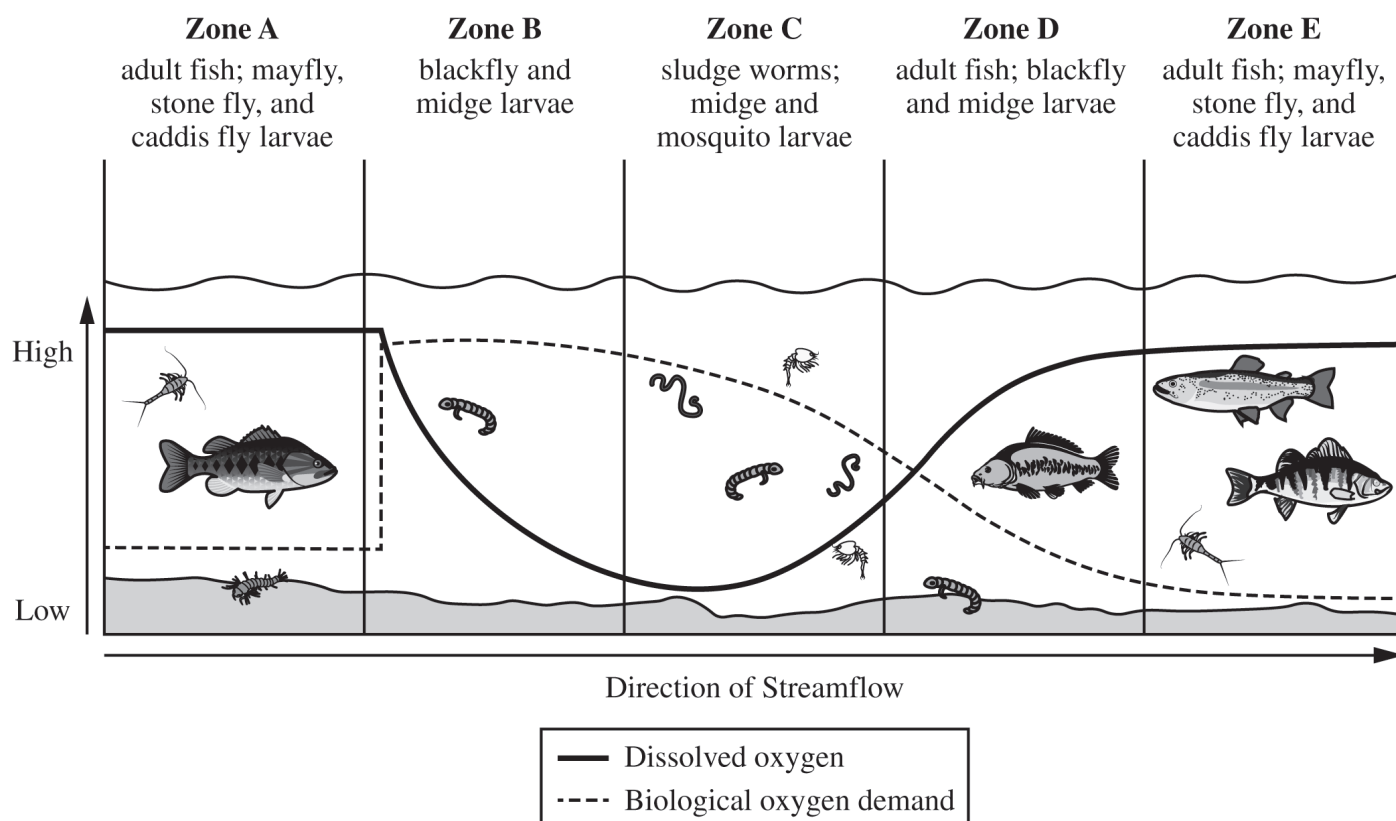
SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen..
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.
- (c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

- (d) **Identify** the dependent variable in the researchers' investigation.
- (e) **Identify** a testable hypothesis for the researchers' investigation.
- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

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Stream ecosystems are affected by point-source organic pollution in a variety of ways.

- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.
- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

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.

ENVIRONMENTAL SCIENCE

SECTION II

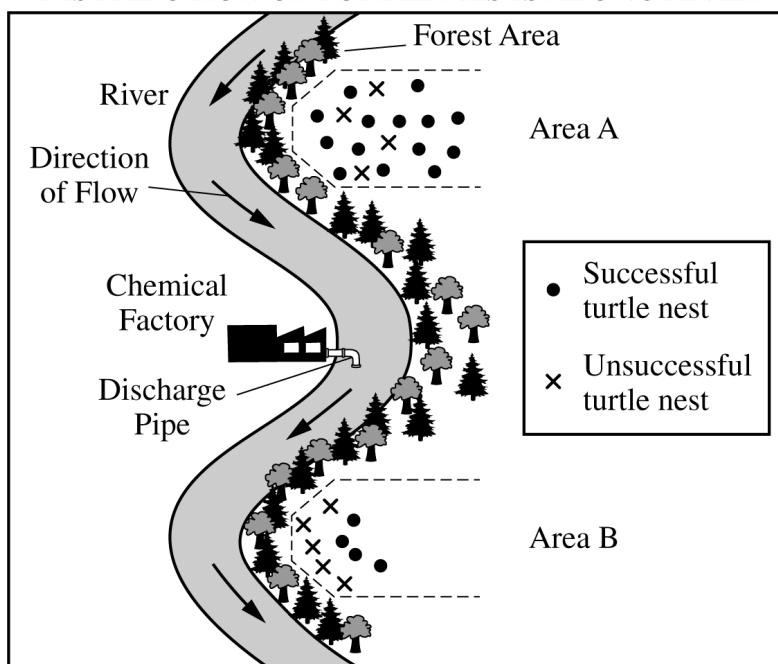
Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Common snapping turtles, *Chelydra serpentina*, are primarily aquatic, but they lay their eggs on land. Researchers are interested in understanding the impact of pollution on turtle nesting sites. The researchers examined nesting sites at two agricultural areas along the floodplain of a river upstream and downstream from a chemical factory that is a known source of aqueous mercury pollution. Turtle eggs, soil, and vegetation samples taken from areas around turtle nests downstream from the chemical factory showed high levels of mercury in a previous study. Mercury was not detected in samples taken upstream from the chemical factory.

DISTRIBUTION OF TURTLE NESTS ALONG RIVER



- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
 - (ii) **Identify** the dependent variable in the study.
 - (iii) Based on the information provided, **identify** a likely scientific question for the study.
 - (iv) **Describe** why researchers measured mercury levels in locations upstream from the factory.
 - (v) There are plans to remove trees and other vegetation along the river bank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B.
- (b) Mercury can affect organisms and ecosystems in many ways.
- (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism.
 - (ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem.
 - (iii) Researchers measured methylmercury in a location downstream from the factory. **Explain** how methylmercury could be present in the stream.
 - (iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **Explain** how the pattern shown in the diagram supports or refutes this claim.
- (c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area.

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.

2. Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

- (a) Pesticide use has advantages, disadvantages, and unintended consequences on human health. **Describe** one benefit to human health that can result from the use of pesticides.
- (b) **Identify** one way chemical pesticides can enter the human body.

Cotton farmers in the southern United States used a chemical pesticide to control an insect cotton-crop pest over a 40-year period. To study the effectiveness of the pesticide as an insect pest-control strategy, traps were placed in treated cotton fields and the number of pests captured were compared to application rates for the pesticide. The results of the study are shown in the table below.

Year	Grams of Pesticide Applied per Hectare	Number of Crop Insect Pests Captured
1960	0	700
1975	500	2
1980	500	3
1985	500	8
1990	550	14
1995	600	83
2000	700	150
2005	800	405
2010	900	727
2015	1,000	1,100

- (c) Use the data in the table to answer the following questions.
- (i) **Identify** the year when the pesticide was most effective at reducing the size of the pest population.
- (ii) **Describe** the change in the number of crop insect pests in the cotton fields over time.
- (iii) **Explain** how the change in the cotton-crop pesticide effectiveness between the initial application in 1975 and the latest application in 2015 illustrates genetic resistance in pests, based on the data in the table.
- (d) **Describe** TWO effects of pesticide use, other than death, on nontarget wildlife.

- (e) There are many problems associated with the repeated application of chemical pesticides to reduce pest populations.
- (i) Crop rotation is often used to reduce pesticide use. **Describe** the process of crop rotation.
- (ii) **Propose** one reasonable method, other than crop rotation, of reducing the use of pesticides in agricultural practices while still maintaining a high crop yield.
- (iii) **Justify** how the method proposed in (e)(ii) would provide a benefit to humans.

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.

8.9 Solid Waste Disposal

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS incineration 焚烧 • leachate 渗滤液 • sanitary landfills 卫生填埋场

Objective

Build the skills to answer exam questions on **solid waste disposal**.

You must be able to:

- describe **sanitary landfills** 卫生填埋场 and **incineration** 焚烧
- state the pros and cons of each
- explain **leachate** 渗滤液 and methane

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Sanitary landfills

A **sanitary landfill** buries waste with a **liner** (to stop leaks) and daily soil cover. Concerns:

- **Leachate** — liquid that seeps through waste, which can contaminate groundwater if the liner fails.
- **Methane** — produced as waste decomposes (a greenhouse gas; can be captured for energy).

■ Incineration

Incineration burns waste, **reducing its volume** and able to generate energy, but releases **air pollutants** and leaves toxic **ash**.

■ Trade-offs

- **Landfill** — cheaper, but uses land and risks leachate/methane.
- **Incineration** — less volume/land, but air pollution and cost.

■ A worked judgement

A landfill saves money but must be lined and monitored to prevent leachate polluting groundwater and to capture methane.

2 Practice

Now apply the methods above.

2.1 What is leachate? [1]

2.2 What gas is produced as landfill waste decomposes? [1]

2.3 State one advantage of incineration. [1]

3 Exam-style questions

3.1 A liner is placed at the bottom of a landfill to [1]

- **A** produce methane
 - **B** stop leachate contaminating groundwater
 - **C** burn the waste
 - **D** add nutrients
-

3.2 A city debates a landfill vs an incinerator.

(a) State one advantage and one disadvantage of the landfill. [2]

(b) State one advantage and one disadvantage of the incinerator. [2]

3.3 Explain how landfill methane can be turned from a problem into a resource. [2]

Solutions

2.1 Liquid that seeps through waste and can pollute groundwater.

2.2 Methane.

2.3 Any one: reduces waste volume, can generate energy.

3.1 B — stop leachate contaminating groundwater.

3.2 (a) Landfill — advantage: cheap; disadvantage: uses land / leachate / methane. (b) Incinerator — advantage: reduces volume / energy; disadvantage: air pollution / toxic ash / cost.

3.3 The methane can be **captured** and burned as fuel to generate electricity, turning a greenhouse-gas problem into an energy source.

3. Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

(a) **Describe** one environmental problem associated with the release of methane into the atmosphere.

There are biological and physical factors that can affect the decomposition of the solid waste in a landfill and the release of methane in the atmosphere.

(b) **Describe** one factor that could affect the decomposition of the solid waste in a landfill.

(c) **Propose** a solution to decrease the amount of methane released from landfills into the atmosphere.

(d) **Justify** the solution proposed in part (c) by describing an additional advantage, other than decreasing the amount of methane released from landfills.

Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

(e) The average cow releases 150 liters of methane per day. **Calculate** the amount of methane that was released by all beef cattle raised in the United States in 2021. **Show** your work.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(f) A typical beef cow needs 11.8 kilograms of food per day, and each hectare of cattle pasture produces 26.2 kilograms of grasses. **Calculate** the number of hectares of pasture that would be needed to support all beef cattle raised in the United States for one day. **Show** your work.

(g) The average American consumes 2,250 kilocalories of food per day. Beef cattle can produce 2.7 million kilocalories per hectare of land. Corn can produce 30.4 million kilocalories per hectare of land. **Calculate** how many more American people could be fed if 150 hectares of land was used to grow corn instead of raising beef cattle. **Show** your work.

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.

STOP

END OF EXAM

3. North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

- (a) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal.
- (b) Coal ash, the powdery, solid substance that remains after coal combustion, presents a variety of potential environmental issues. Disposal of toxic coal ash is a growing concern in the state. Coal ash can be mixed with water and disposed of in large, unlined pits or as dry ash in landfills.
- (i) **Describe** an environmental problem associated with coal ash waste disposal.
- (ii) A proposed solution is to dispose of North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil.
- (c) The population of Charlotte, North Carolina, has grown over the last few decades. The table shows the increase in the population size of Charlotte from 2013 to 2019.

Population of Charlotte, North Carolina, 2013–2019

Year	Population
2013	757,278
2014	774,807
2015	792,137
2016	808,834
2017	826,060
2018	841,611
2019	857,425

- (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work.
- (ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work.
- (iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work.
- (d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use.

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.

STOP

END OF EXAM



ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 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 Daily Times* and answer the questions that follow.

Fremont Daily Times**May 1, 2018****GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!**

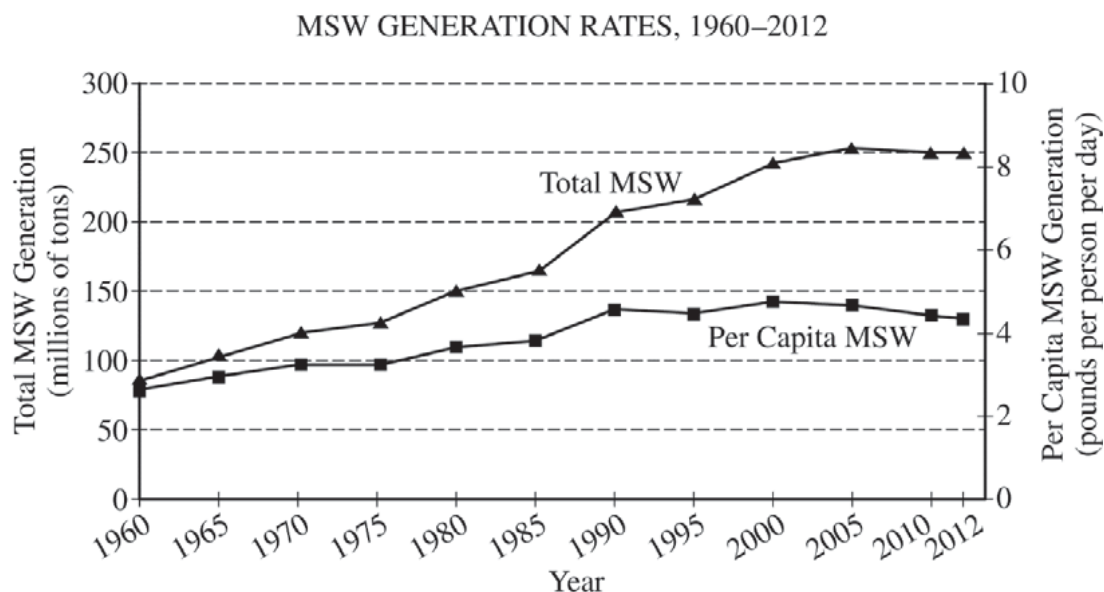
A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- Identify** one disadvantage of waste incineration.
 - Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- Other than reducing the volume of waste, **identify** one advantage of composting.
 - Identify** one disadvantage of composting.

2. Approximately 30 million mobile devices were sold in 1998 in the United States. The number sold increased to 180 million devices in 2007.
- (a) **Calculate** the percent increase of mobile device sales from 1998 to 2007.
 - (b) Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.
 - (c) Assume that the average mass of each mobile device was 0.1 kilogram. The United States Environmental Protection Agency estimates that about 10 percent of the mobile devices sold in 2007 were recycled. **Calculate** the mass (in kilograms) of the mobile devices sold in 2007 that were not recycled.
 - (d) Discarded mobile devices become part of the electronic waste stream (e-waste). Mercury is often present in e-waste. **Identify** one negative human health effect, other than death, associated with exposure to mercury.
 - (e) Improper disposal of e-waste has harmed human health and caused environmental damage in developing countries.
 - (i) **State TWO** reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.
 - (ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.

8.10 Waste Reduction Methods

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS composting 堆肥 • reduce, reuse, recycle 减量、再利用、回收

Objective

Build the skills to answer exam questions on **waste reduction methods**.

You must be able to:

- apply the **three Rs** (reduce, reuse, recycle) and **composting** 堆肥
- explain the **waste hierarchy** (reduce is best)
- describe benefits of each method

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The waste hierarchy

Best to worst: **Reduce** → **Reuse** → **Recycle** → **(Recover energy)** → **Dispose**.
Preventing waste in the first place (**reduce**) is best.

■ The three Rs

- **Reduce** — use less / buy less packaging.
- **Reuse** — use items again (refillable bottles).
- **Recycle** — process materials into new products (paper, glass, metal, plastic).

■ Composting

Composting turns food and yard waste into fertilizer, keeping organic matter out of landfills (where it would make methane) and enriching soil.

■ Benefits

Waste reduction saves **landfill space**, **energy**, and **raw materials**, and cuts pollution and greenhouse gases.

2 Practice

Now apply the methods above.

2.1 State the three Rs in order (best first). [1]

2.2 What does composting turn waste into? [1]

2.3 Which R is the most effective? [1]

3 Exam-style questions

3.1 In the waste hierarchy, the best option is to [1]

- **A** dispose
 - **B** recycle
 - **C** reduce
 - **D** incinerate
-

3.2 A household wants to cut its waste.

(a) Give one example each of reducing, reusing, and recycling. [3]

(b) Explain one environmental benefit of composting food scraps. [1]

3.3 Explain why “reduce” is more effective than “recycle”. [2]

Solutions

2.1 Reduce, reuse, recycle.

2.2 Compost (fertilizer / soil enrichment).

2.3 Reduce.

3.1 C — reduce.

3.2 (a) Reduce: buy less/less packaging; reuse: refillable bottle; recycle: paper/glass/metal.

(b) It keeps organics out of landfills (avoiding methane) and enriches soil.

3.3 Reducing prevents the waste (and the energy/materials to make and process it) entirely, while recycling still uses energy to collect and reprocess the material.

3. Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

(a) **Describe** one environmental problem associated with the release of methane into the atmosphere.

There are biological and physical factors that can affect the decomposition of the solid waste in a landfill and the release of methane in the atmosphere.

(b) **Describe** one factor that could affect the decomposition of the solid waste in a landfill.

(c) **Propose** a solution to decrease the amount of methane released from landfills into the atmosphere.

(d) **Justify** the solution proposed in part (c) by describing an additional advantage, other than decreasing the amount of methane released from landfills.

Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

(e) The average cow releases 150 liters of methane per day. **Calculate** the amount of methane that was released by all beef cattle raised in the United States in 2021. **Show** your work.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(f) A typical beef cow needs 11.8 kilograms of food per day, and each hectare of cattle pasture produces 26.2 kilograms of grasses. **Calculate** the number of hectares of pasture that would be needed to support all beef cattle raised in the United States for one day. **Show** your work.

(g) The average American consumes 2,250 kilocalories of food per day. Beef cattle can produce 2.7 million kilocalories per hectare of land. Corn can produce 30.4 million kilocalories per hectare of land. **Calculate** how many more American people could be fed if 150 hectares of land was used to grow corn instead of raising beef cattle. **Show** your work.

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.

STOP

END OF EXAM

ENVIRONMENTAL SCIENCE**SECTION II****Time—1 hour and 30 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 Daily Times* and answer the questions that follow.

Fremont Daily Times**May 1, 2018****GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!**

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize

renewable energy sources can help reduce the carbon footprint.

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a “shining beacon” of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

- (a) The students want to reduce the school's carbon footprint.
- (i) **Define** carbon footprint.
 - (ii) **Identify** one way the school's heating system is likely adding to the school's carbon footprint.
 - (iii) **Describe** one realistic way to reduce the contribution of the heating system to the school's carbon footprint.
- (b) **Identify** TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.
- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.
- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

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 Daily Times* and answer the questions that follow.

Fremont Daily Times

Scientists Discuss Threats from Plastic Pollution

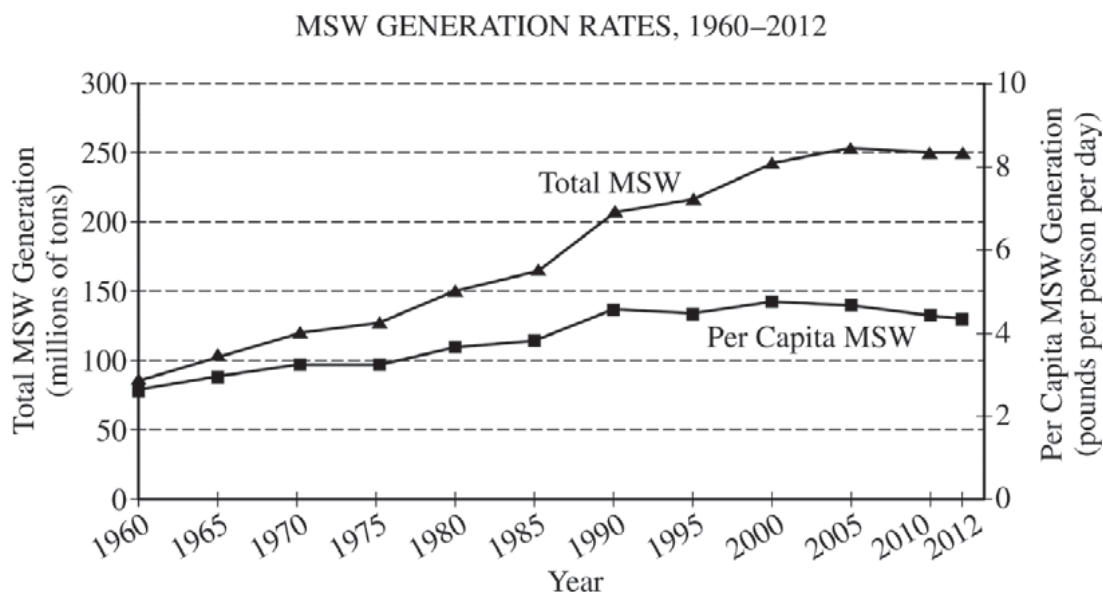
In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake

them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

- (a) **Describe** TWO effects that ingesting microbeads has on aquatic organisms.
- (b) Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. **Describe** how nitrate levels can negatively affect water quality in some aquatic ecosystems.
- (c) While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants.
- (i) **Identify** one way large pieces of plastic are removed from wastewater during primary treatment.
 - (ii) Prior to discharge, wastewater is often disinfected. **Identify** one technique commonly used to disinfect wastewater.
 - (iii) Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. **Identify** one advantage and one disadvantage of this practice.
- (d) Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem.
- (i) **Provide** one reason why mangrove trees are being removed by humans.
 - (ii) **Identify** one ecosystem service provided by intact mangrove ecosystems.

3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- Identify** one disadvantage of waste incineration.
 - Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- Other than reducing the volume of waste, **identify** one advantage of composting.
 - Identify** one disadvantage of composting.

2. Approximately 30 million mobile devices were sold in 1998 in the United States. The number sold increased to 180 million devices in 2007.
- (a) **Calculate** the percent increase of mobile device sales from 1998 to 2007.
 - (b) Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.
 - (c) Assume that the average mass of each mobile device was 0.1 kilogram. The United States Environmental Protection Agency estimates that about 10 percent of the mobile devices sold in 2007 were recycled. **Calculate** the mass (in kilograms) of the mobile devices sold in 2007 that were not recycled.
 - (d) Discarded mobile devices become part of the electronic waste stream (e-waste). Mercury is often present in e-waste. **Identify** one negative human health effect, other than death, associated with exposure to mercury.
 - (e) Improper disposal of e-waste has harmed human health and caused environmental damage in developing countries.
 - (i) **State TWO** reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.
 - (ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.

8.11 Sewage Treatment

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS primary 一级 • tertiary 三级 • secondary 二级 • pathogens 病原体
• sewage treatment 污水处理

Objective

Build the skills to answer exam questions on **sewage treatment**.

You must be able to:

- describe **primary** 一级, **secondary** 二级, and **tertiary** 三级 treatment
- state what each stage removes
- explain why treatment protects water

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The stages

- **Primary** — **physical** removal: screening and settling out solids (sludge).
- **Secondary** — **biological**: bacteria break down dissolved organic matter (reducing oxygen demand).
- **Tertiary** — **advanced**: removes remaining nutrients (nitrogen, phosphorus) and disinfects (often with chlorine or UV).

■ Why treat sewage

Untreated sewage adds **nutrients** (eutrophication), **pathogens** (disease), and **oxygen-demanding** organic matter to water. Treatment removes these before release.

■ A worked order

Sewage first settles (primary), then bacteria digest the organics (secondary), then nutrients are removed and the water is disinfected (tertiary) before discharge.

■ Sludge

The settled **sludge** is treated separately (digested), and can be used as fertilizer or disposed of.

2 Practice

Now apply the methods above.

2.1 What does primary treatment remove? [1]

2.2 What does secondary treatment use to break down organic matter? [1]

2.3 What does tertiary treatment remove? [1]

3 Exam-style questions

3.1 Bacteria are used to break down dissolved organic matter in [1]

- **A** primary treatment
 - **B** secondary treatment
 - **C** tertiary treatment
 - **D** no treatment
-

3.2 A treatment plant processes sewage before releasing water to a river.

(a) Name the three treatment stages in order. [3]

(b) Explain why releasing untreated sewage would harm the river. [2]

3.3 Explain why tertiary treatment is important for preventing eutrophication. [2]

Solutions

2.1 Solids (by settling/screening).

2.2 Bacteria (biological breakdown).

2.3 Nutrients (nitrogen, phosphorus) and pathogens (disinfection).

3.1 B — secondary treatment.

3.2 (a) Primary, secondary, tertiary. (b) Untreated sewage adds nutrients (eutrophication), pathogens (disease), and oxygen-demanding matter, harming aquatic life and human health.

3.3 Tertiary treatment removes the nitrogen and phosphorus that would otherwise fertilize algae, preventing algal blooms and eutrophication downstream.

ENVIRONMENTAL SCIENCE

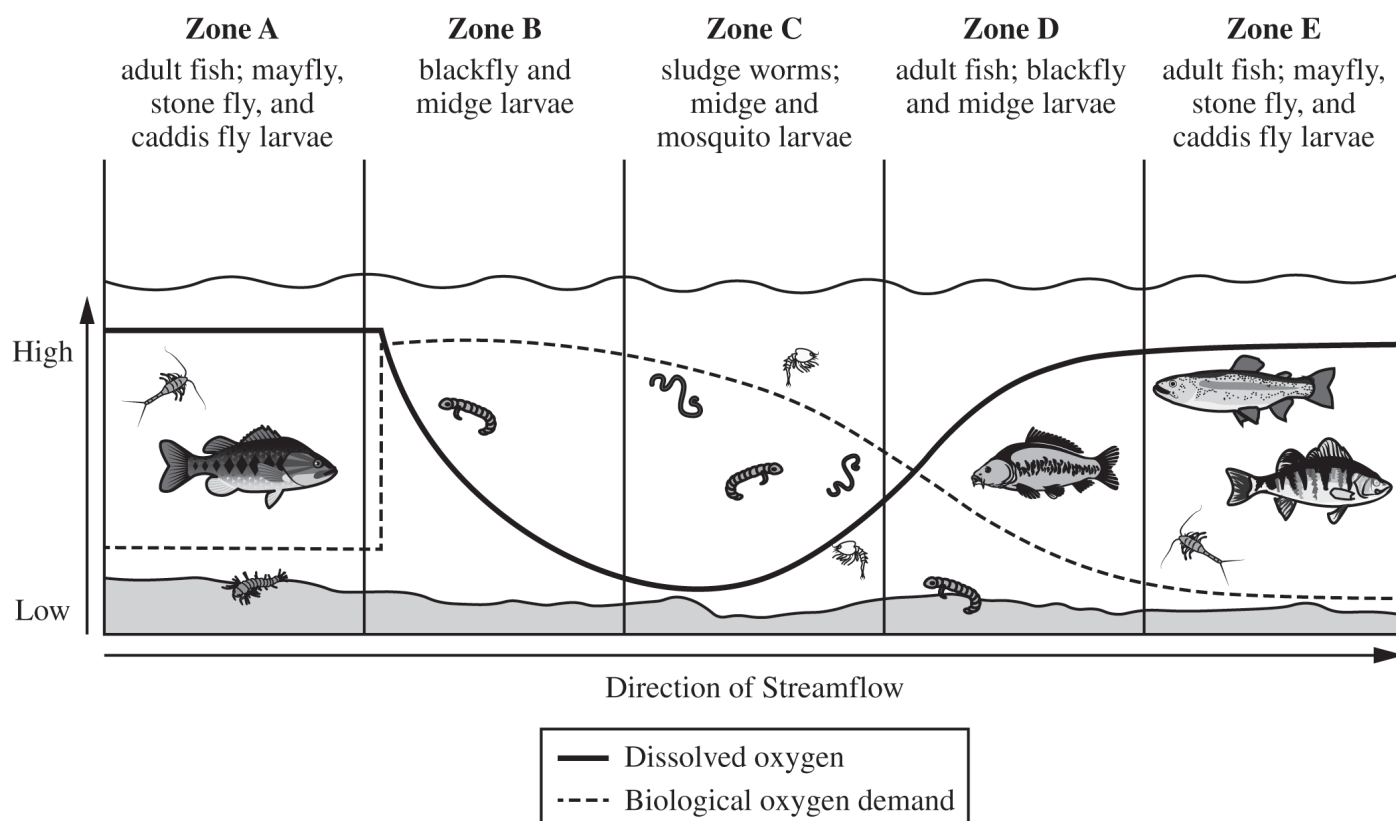
SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response 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. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen..
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.
- (c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

- (d) **Identify** the dependent variable in the researchers' investigation.
- (e) **Identify** a testable hypothesis for the researchers' investigation.
- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

- (g) **Explain** how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.
- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

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.

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.

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Fremont Daily Times

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- (i) **Provide** one reason why mangrove trees are being removed by humans.
 - (ii) **Identify** one ecosystem service provided by intact mangrove ecosystems.

2. Like many communities, Fremont has a combined sewer system that collects both sewage and storm water. When storm water runs into storm drains that connect to the city's sanitary sewer system, the storm water and sewage flow together to the Fremont Wastewater Treatment Plant (FWTP). During a major storm event, however, the combined volume of storm water and sewage may exceed the plant's capacity, and the overflow bypasses the FWTP. The untreated overflow is discharged into Fremont Creek along with the treated waste.

Recently parts of Fremont received 5 cm of rain in 60 minutes. The storm caused widespread flooding in the northeast section of town. Especially hard hit was the Shoppes at Fremont shopping center.

Use the data from the table below to answer the questions that follow. Show all calculations.

Fremont Water Data
The shopping center's parking lot is 200 meters long and 100 meters wide.
Fremont has an area of 10 km^2 .
Impervious surfaces cover 20 percent of Fremont's area.
The FWTP typically treats $5,000 \text{ m}^3$ of domestic sewage per day.
The FWTP has the capacity to treat $10,000 \text{ m}^3$ of combined sewage and storm water per day.

- (a) **Identify** TWO specific pollutants in storm-water runoff that degrade the quality of surface water.
- (b) **Calculate** the volume of water (in m^3) that runs off the Shoppes at Fremont parking lot after a 5 cm rainfall event. Assume that all the water that falls on the parking lot runs off.
- (c) **Calculate** the volume of storm-water runoff (in m^3) generated in all of Fremont by the 5 cm rainfall event. Assume that only the impervious surfaces generate runoff.
- (d) Assume that all the runoff that you calculated in part (c) is captured by the storm sewers in one day. **Calculate** the volume of untreated water (in m^3) that bypasses the plant as a result of the storm. (Note that the plant still receives $5,000 \text{ m}^3$ of domestic sewage per day.)
- (e) **Describe** TWO ways that the volume of storm-water runoff can be reduced.
- (f) **Describe** one environmental problem (other than pollution from runoff and from untreated sewage) that results from having extensive paved areas.

8.12 Lethal Dose 50% (LD50)

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS ld50 半数致死量

Objective

Build the skills to answer exam questions on **LD50** (lethal dose 50%).

You must be able to:

- define **LD50** 半数致死量
- interpret LD50 values (lower = more toxic)
- compare the toxicity of substances

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ What LD50 is

LD50 is the **dose that kills 50%** of a test population, usually given in mg of substance per kg of body weight (**mg/kg**). It measures a chemical's **acute toxicity**.

■ Lower LD50 = more toxic

A **lower** LD50 means **less** substance is needed to be lethal, so it is **more toxic**. A **higher** LD50 means it takes more, so it is **less toxic**.

■ A worked comparison

Substance A has LD50 = 5 mg/kg; substance B has LD50 = 500 mg/kg. **A is more toxic** — far less is needed to kill.

■ Dose for a person

To estimate a lethal dose for a 70 kg person from LD50 = 5 mg/kg: $5 \times 70 = 350$ mg (rough guide from animal data).

2 Practice

Now apply the methods above.

2.1 Define LD50. [1]

2.2 Does a lower or higher LD50 mean more toxic? [1]

2.3 Substance X (LD50 = 2 mg/kg) vs Y (LD50 = 200 mg/kg): which is more toxic? [1]

3 Exam-style questions

3.1 A chemical with a very low LD50 is [1]

- **A** very toxic
 - **B** not toxic
 - **C** a nutrient
 - **D** harmless
-

3.2 Two pesticides have LD50 values of 10 mg/kg and 1000 mg/kg.

(a) State which is more toxic, with a reason. [2]

(b) Estimate the lethal dose for a 60 kg person from the 10 mg/kg value. [2]

3.3 Explain why LD50 is measured in mg per kg of body weight rather than just mg. [2]

Solutions

2.1 The dose that kills 50% of a test population.

2.2 Lower.

2.3 X ($\text{LD}_{50} = 2 \text{ mg/kg}$).

3.1 A — very toxic.

3.2 (a) The 10 mg/kg pesticide — a lower LD_{50} means less is needed to be lethal, so it is more toxic. (b) $10 \times 60 = 600 \text{ mg}$.

3.3 A larger animal needs more of a substance to be affected, so expressing the dose per kg of body weight makes toxicity comparable across different body sizes.

8.13 Dose Response Curve

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS threshold 阈值 • dose-response curve 剂量反应曲线

Objective

Build the skills to answer exam questions on **dose-response curves**.

You must be able to:

- read a **dose-response curve** 剂量反应曲线
- identify the **threshold** 阈值 dose
- explain the difference between threshold and linear (no-threshold) responses

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ The dose-response curve

A **dose-response curve** plots the **effect (response)** against the **dose**. Usually a higher dose gives a larger response.

■ Threshold

Many substances have a **threshold** dose — below it there is **no observable effect**; above it, the response rises. This is common for nutrients and many toxins.

■ No-threshold (linear)

Some agents (like certain **carcinogens** and radiation) are assumed to have **no safe threshold** — any dose carries some risk, and response rises roughly linearly from zero.

■ A worked reading

If a curve stays flat until dose 5, then rises, the **threshold is 5** — below it there is no effect. A curve rising straight from zero has **no threshold**.

2 Practice

Now apply the methods above.

2.1 What does a dose-response curve plot? [1]

2.2 What is a threshold dose? [1]

2.3 What is assumed about a no-threshold agent? [1]

3 Exam-style questions

3.1 A substance with a threshold dose has [1]

- **A** an effect at any dose
 - **B** no effect below a certain dose
 - **C** the same effect at all doses
 - **D** no effect ever
-

3.2 A dose-response curve is flat up to a dose of 20 mg, then rises.

(a) State the threshold dose. [1]

(b) Explain what happens below and above it. [2]

3.3 Explain why some carcinogens are treated as having no safe threshold. [2]

Solutions

2.1 The effect (response) against the dose.

2.2 A dose below which there is no observable effect.

2.3 Any dose carries some risk (no safe level).

3.1 B — no effect below a certain dose.

3.2 (a) 20 mg. (b) Below 20 mg there is no observable effect; above it, the response increases with dose.

3.3 Even a single exposure could damage DNA and start a cancer, so any dose is assumed to carry some risk — there is no dose considered completely safe.

8.14 Pollution and Human Health

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS chronic 慢性 • acute 急性

Objective

Build the skills to answer exam questions on **pollution and human health**.

You must be able to:

- distinguish **acute** 急性 and **chronic** 慢性 exposure
- classify health effects (carcinogens, neurotoxins, teratogens)
- link specific pollutants to health outcomes

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Acute vs chronic

- **Acute exposure** — a single, short, high-dose exposure (e.g. a chemical spill).
- **Chronic exposure** — repeated, low-dose exposure over a long time (e.g. living near a polluted site).

■ Types of harmful agents

- **Carcinogens** — cause cancer (e.g. asbestos, some POPs).
- **Neurotoxins** — damage the nervous system (e.g. lead, mercury).
- **Teratogens** — cause birth defects (e.g. some chemicals, alcohol).

■ Specific links

- **Lead** — brain damage, especially in children.
- **Mercury** — nervous-system damage (from contaminated fish).
- **Particulates** — respiratory and heart disease.

■ A worked classification

Lead is a **neurotoxin**; long-term low-level exposure in old paint or pipes is **chronic** and especially harms children's brain development.

2 Practice

Now apply the methods above.

2.1 Distinguish acute from chronic exposure. [2]

2.2 What is a carcinogen? [1]

2.3 Name one neurotoxin. [1]

3 Exam-style questions

3.1 A substance that causes birth defects is a [1]

- **A** carcinogen
- **B** neurotoxin
- **C** teratogen
- **D** nutrient

3.2 Children in old housing are exposed to lead paint over many years.

(a) State whether this is acute or chronic exposure. [1]

(b) Classify lead's health effect and explain the concern for children. [2]

3.3 Explain why chronic low-dose exposure can be hard to detect but still harmful. [2]

Solutions

2.1 Acute is a single short high-dose exposure; chronic is repeated low-dose exposure over a long time.

2.2 A substance that causes cancer.

2.3 Any one: lead, mercury.

3.1 C — a teratogen.

3.2 (a) Chronic. (b) Lead is a neurotoxin; it damages the developing brain, so children are especially at risk of learning and developmental problems.

3.3 The effects build up slowly and may resemble other conditions, so the cause is hard to identify, yet the accumulated damage can be serious.

3. Crude oil is extracted, transported, and refined for various uses by humans.

- (a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil.
- (b) **Identify** an atmospheric pollutant released during the combustion of refined oil products.
- (c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation.
- (d) **Justify** the solution proposed in part (c) by providing a benefit to human health.

Other natural resources, such as gold and silver, are also extracted. These resources can be used to make components for the electronics humans use. One metric ton of gold ore contains 5.0 grams of gold.

- (e) A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work.
- (f) Assuming the price of gold is \$62.56 per gram, **calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work.
- (g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold ore would need to be mined to extract enough gold to manufacture 100,000 cell phones. **Show** your work.

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.

STOP

END OF EXAM

3. North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

- (a) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal.
- (b) Coal ash, the powdery, solid substance that remains after coal combustion, presents a variety of potential environmental issues. Disposal of toxic coal ash is a growing concern in the state. Coal ash can be mixed with water and disposed of in large, unlined pits or as dry ash in landfills.
- (i) **Describe** an environmental problem associated with coal ash waste disposal.
- (ii) A proposed solution is to dispose of North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil.
- (c) The population of Charlotte, North Carolina, has grown over the last few decades. The table shows the increase in the population size of Charlotte from 2013 to 2019.

Population of Charlotte, North Carolina, 2013–2019

Year	Population
2013	757,278
2014	774,807
2015	792,137
2016	808,834
2017	826,060
2018	841,611
2019	857,425

- (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work.
- (ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work.
- (iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work.
- (d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use.

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.

STOP

END OF EXAM

2. Pesticides have been utilized for many years to increase food production and control pest populations. Pesticide use can be both beneficial and harmful to humans and other organisms.

- (a) Pesticide use has advantages, disadvantages, and unintended consequences on human health. **Describe** one benefit to human health that can result from the use of pesticides.
- (b) **Identify** one way chemical pesticides can enter the human body.

Cotton farmers in the southern United States used a chemical pesticide to control an insect cotton-crop pest over a 40-year period. To study the effectiveness of the pesticide as an insect pest-control strategy, traps were placed in treated cotton fields and the number of pests captured were compared to application rates for the pesticide. The results of the study are shown in the table below.

Year	Grams of Pesticide Applied per Hectare	Number of Crop Insect Pests Captured
1960	0	700
1975	500	2
1980	500	3
1985	500	8
1990	550	14
1995	600	83
2000	700	150
2005	800	405
2010	900	727
2015	1,000	1,100

- (c) Use the data in the table to answer the following questions.
- (i) **Identify** the year when the pesticide was most effective at reducing the size of the pest population.
- (ii) **Describe** the change in the number of crop insect pests in the cotton fields over time.
- (iii) **Explain** how the change in the cotton-crop pesticide effectiveness between the initial application in 1975 and the latest application in 2015 illustrates genetic resistance in pests, based on the data in the table.
- (d) **Describe** TWO effects of pesticide use, other than death, on nontarget wildlife.

- (e) There are many problems associated with the repeated application of chemical pesticides to reduce pest populations.
- (i) Crop rotation is often used to reduce pesticide use. **Describe** the process of crop rotation.
- (ii) **Propose** one reasonable method, other than crop rotation, of reducing the use of pesticides in agricultural practices while still maintaining a high crop yield.
- (iii) **Justify** how the method proposed in (e)(ii) would provide a benefit to humans.

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.

3. Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

- (a) **Describe** why coal is considered a nonrenewable energy source.
- (b) **Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant.
- (c) **Describe** one economic advantage of using natural gas, rather than coal, in producing electricity.
- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans.

Particulate matter is another common pollutant in emissions from vehicles, coal-fired power plants, and various other sources. One size of particulates, $\text{PM}_{2.5}$, presents a particular risk to human health.

ATMOSPHERIC CONCENTRATION OF PARTICULATE MATTER IN 1990 AND 2016

Year	Average Annual Atmospheric Concentration of $\text{PM}_{2.5}$ ($\mu\text{g}/\text{m}^3$)
1990	85
2016	188

- (e) **Calculate** the percent change in the average annual $\text{PM}_{2.5}$ concentration in the air from 1990 to 2016. **Show** your work.
- (f) Trees can remove $\text{PM}_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $\text{PM}_{2.5}$ is 2.3 kilograms per hectare. **Calculate** the decrease in $\text{PM}_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work.
- (g) Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in $\text{PM}_{2.5}$ concentration. A city experienced a 23% increase in $\text{PM}_{2.5}$ concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the $\text{PM}_{2.5}$ concentration continues to rise at an identical rate. **Show** your work.

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.

Name:

STOP

END OF EXAM

4. In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

- (a) Air pollutants are released during the burning of biomass indoors for cooking and heating.
- (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.
- (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.
- (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

- (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

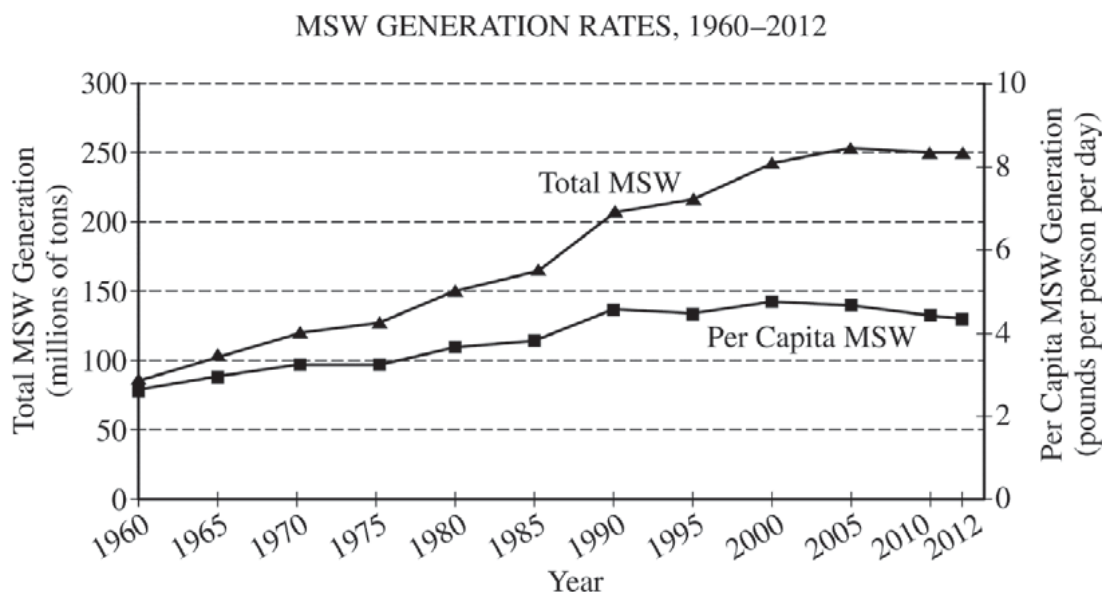
- asbestos
 - radon
 - mold
- (d) Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.
- (i) **Identify** a source for each indoor air pollutant.
- (ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

Indoor Air Pollutant	Source	Method for Reducing Exposure

STOP

END OF EXAM

3. Municipal solid waste (MSW) is the trash collected from households and businesses. The graph below shows MSW generation in the United States from 1960 to 2012.



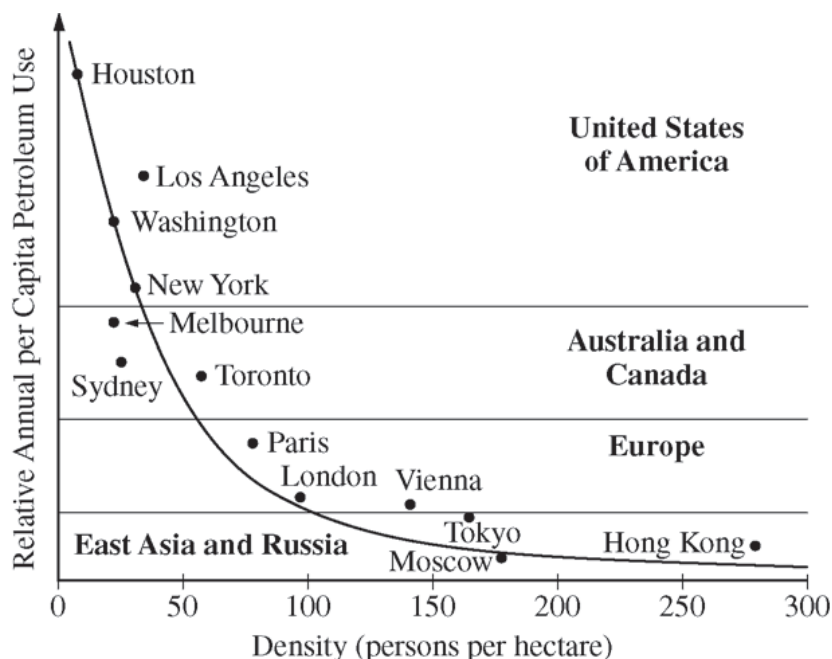
- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
 - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways of managing MSW are incineration and disposal in landfills.
- Identify** one disadvantage of waste incineration.
 - Identify** one disadvantage of waste disposal in landfills.

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

- (c) **Describe** the specific steps of a process used to produce electricity from waste buried in a landfill.
- (d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
- (e) Composting is one way to reduce the amount of waste that enters a landfill.
- Other than reducing the volume of waste, **identify** one advantage of composting.
 - Identify** one disadvantage of composting.

2. Approximately 30 million mobile devices were sold in 1998 in the United States. The number sold increased to 180 million devices in 2007.
- (a) **Calculate** the percent increase of mobile device sales from 1998 to 2007.
 - (b) Each mobile device sold in 2007 contained an average of 0.03 gram of gold. **Calculate** the number of grams of gold that were used in the production of the mobile devices sold in 2007.
 - (c) Assume that the average mass of each mobile device was 0.1 kilogram. The United States Environmental Protection Agency estimates that about 10 percent of the mobile devices sold in 2007 were recycled. **Calculate** the mass (in kilograms) of the mobile devices sold in 2007 that were not recycled.
 - (d) Discarded mobile devices become part of the electronic waste stream (e-waste). Mercury is often present in e-waste. **Identify** one negative human health effect, other than death, associated with exposure to mercury.
 - (e) Improper disposal of e-waste has harmed human health and caused environmental damage in developing countries.
 - (i) **State TWO** reasons why large quantities of e-waste from the United States are shipped to developing countries rather than being recycled in the United States.
 - (ii) Retailers or manufacturers could take specific steps to dramatically reduce the amount of e-waste. **Describe** a realistic change in current practices that would accomplish this.

4. The term “urban sprawl” describes the expansion of cities into rural areas. This phenomenon has occurred around the world and has had economic, health, and environmental consequences.
- (a) **Describe** TWO causes of urban sprawl.
- (b) **Discuss** TWO human health effects associated with urban sprawl.
- (c) The graph below shows the relationship between population density and petroleum use in selected cities. **Describe** the relationship between population density and petroleum use shown in the graph.



- (d) Smart growth focuses on ways to encourage sustainable urban development. **Describe** TWO steps a municipality could take to encourage smart growth in order to limit urban sprawl.
- (e) Highway systems and urban sprawl often threaten wildlife populations. **Describe** TWO methods to reduce harmful effects on wildlife populations from highways and urban sprawl.
- (f) Urban sprawl often results in the loss of productive agricultural land near cities. **Describe** one practical way to increase food production within urban areas.

STOP

END OF EXAM

8.15 Pathogens and Infectious Diseases

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS infectious 传染性 • cholera 霍乱 • malaria 疟疾 • mosquito 蚊子 • dysentery 痢疾

Objective

Build the skills to answer exam questions on **pathogens and infectious diseases**.

You must be able to:

- distinguish **infectious** 传染性 from **non-infectious** diseases
- give examples of waterborne and vector-borne diseases
- link environmental change to disease spread

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Infectious vs non-infectious

- **Infectious** diseases are caused by **pathogens** (bacteria, viruses, parasites) and can **spread** (e.g. cholera, malaria).
- **Non-infectious** diseases do not spread between people (e.g. cancer, heart disease).

■ Waterborne diseases

Spread by **contaminated water** (poor sanitation): **cholera**, dysentery, typhoid. Clean water and sewage treatment prevent them.

■ Vector-borne diseases

Spread by a **vector** (an organism that carries the pathogen), often insects: **malaria** and dengue (mosquitoes). Controlling the vector controls the disease.

■ Environmental links

Climate change can expand mosquito ranges (spreading malaria); poor **sanitation** spreads waterborne disease; deforestation can increase human-wildlife contact.

2 Practice

Now apply the methods above.

2.1 What causes an infectious disease? [1]

2.2 Give one example of a waterborne disease. [1]

2.3 What is a vector? [1]

3 Exam-style questions

3.1 Malaria is spread by mosquitoes, which act as a [1]

- **A** pathogen
 - **B** vector
 - **C** host only
 - **D** nutrient
-

3.2 A region with poor sanitation has frequent cholera outbreaks.

(a) Explain how cholera spreads there. [2]

(b) State one way to prevent it. [1]

3.3 Explain how climate change could increase the spread of a vector-borne disease. [2]

Solutions

2.1 A pathogen (bacterium, virus, or parasite).

2.2 Any one: cholera, dysentery, typhoid.

2.3 An organism that carries and transmits a pathogen.

3.1 B — a vector.

3.2 (a) Sewage contaminates the drinking water with the cholera bacterium; people drink the contaminated water and become infected, spreading it further. (b) Any one: clean water supply, sewage treatment, sanitation.

3.3 Warmer temperatures can expand the range and breeding season of the vector (e.g. mosquitoes), so the disease reaches new areas and more people.

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 New Tribune*.

Fremont New Tribune**May 2, 2016**

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces.

The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*).

Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

"Little brown bats provide tremendous value to the United States economy every year by the essential services they provide to farmers and other people. We need to understand how this deadly disease spreads and attempt to help reduce its impact on the little brown bat and other bat species," said Dr. Duke Serach of the Fremont office of the United States Fish and Wildlife Service. Dr. Serach concluded with, "It may yet be possible to save the little brown bats, but the remaining population will be alarmingly small."

- (a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.
- (b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.
- (i) **Describe** TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.
 - (ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.
- (c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.
- (d) The Eastern deciduous forest in which the little brown bats live is an important ecosystem. **Identify** TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades.

- (e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.