

HOLIDAY HOMEWORK 假期作业

# AP Environmental Science

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Exercise sheets and past-paper practice, topic by topic.

每个单元：练习卷 + 历年真题。

For class or self-study • no answer keys included.

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# 1 Ecosystems and energy flow – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English       | 中文   | Write it 3 times (English) |       |       |
|---------------|------|----------------------------|-------|-------|
| ecosystem     | 生态系统 | _____                      | _____ | _____ |
| Producers     | 生产者  | _____                      | _____ | _____ |
| Consumers     | 消费者  | _____                      | _____ | _____ |
| food chains   | 食物链  | _____                      | _____ | _____ |
| food web      | 食物网  | _____                      | _____ | _____ |
| trophic level | 营养级  | _____                      | _____ | _____ |

## Recall

You already know how living things depend on each other and their surroundings:

- Plants make food from sunlight; animals eat plants or other animals.
- A food chain shows who eats whom.
- Energy flows through nature and is gradually lost.

This sheet lines up how ecosystems move energy. Each idea has a short worked example.

## New ideas

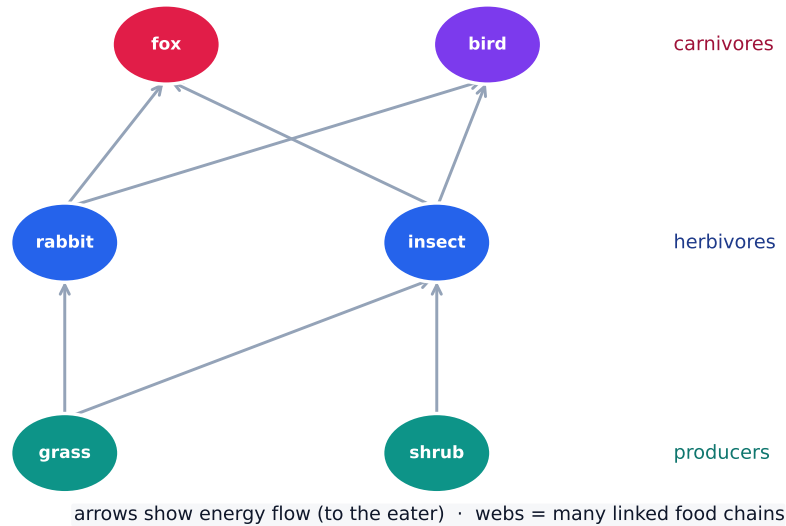
### ■ 1 Ecosystems

An **ecosystem** 生态系统 is all the living things in an area together with their non-living surroundings (water, soil, air). Energy enters as sunlight and flows through the living parts.

## ■ 2 Producers and consumers

- **Producers** 生产者 (plants) capture sunlight to make food.
- **Consumers** 消费者 eat producers or other consumers.

They form **food chains** 食物链 and, joined together, a **food web** 食物网.



## ■ 3 Trophic levels

Each feeding step is a **trophic level** 营养级: producers, then primary, secondary, and tertiary consumers.

## ■ 4 The 10% rule

Only about **10%** of the energy passes from one trophic level to the next; the rest is lost as heat.



*Worked example.* If producers hold 10,000 units of energy, the next level gets about 1,000, then 100 – which is why top predators are few.

**Watch out:** so much energy is lost at each step (about 90%) that food chains rarely have more than four or five levels – there is not enough energy left to support another.

## Practice

Try these in order. The methods are all above.

**2.1** State what an ecosystem includes, both living and non-living. [2]

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**2.2** State the difference between a producer and a consumer. [2]

---



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**2.3** About what percentage of energy passes to the next trophic level? [1]

---

**2.4** A producer level holds 5,000 units of energy. Estimate the energy at the next two

levels.

[2]

**2.5** Explain why food chains are usually short (only a few levels).

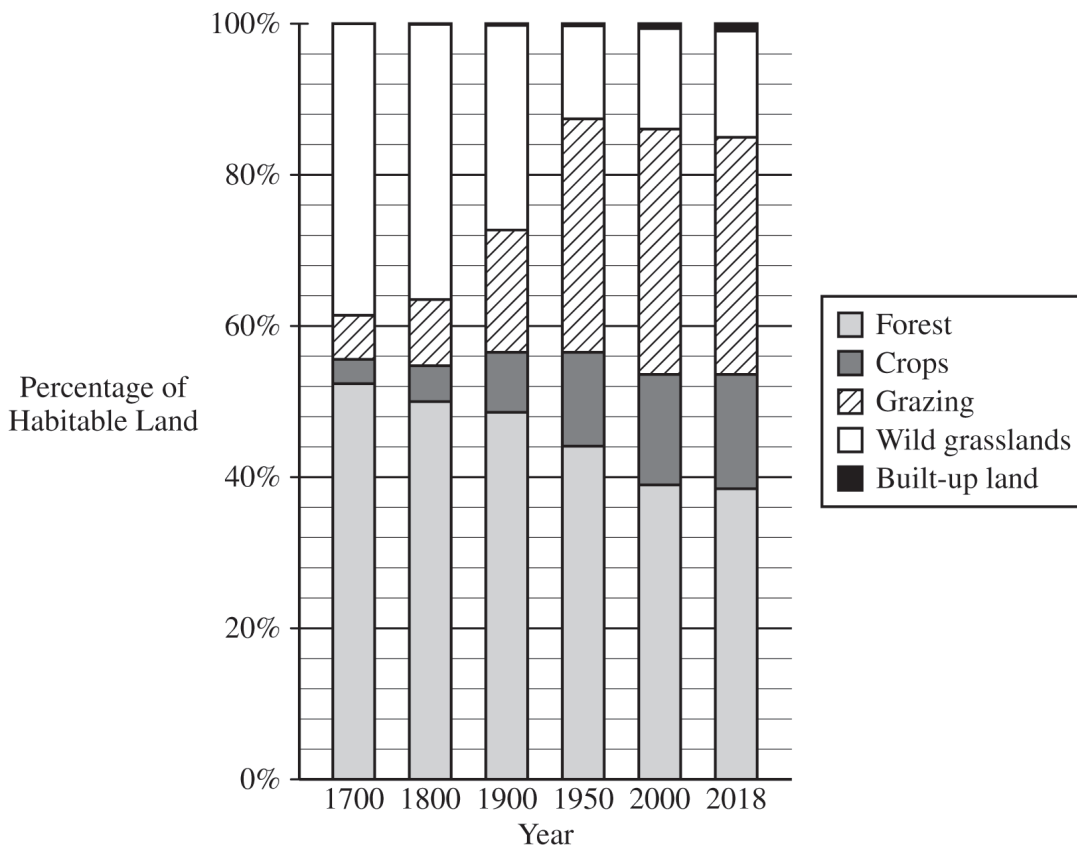
[2]

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

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

2. The following graph shows how global uses of habitable land have changed since 1700.

### Land Use Changes on Earth, 1700–2018



- (a) Based on the data in the graph, **identify** the year with the highest percentage of forest.
- (b) Based on the data in the graph, **describe** the relationship between the land use changes in the wild grasslands and grazing from 1700 to 1950.
- (c) **Identify** an environmental problem associated with overgrazing by livestock.
- (d) A student hypothesized that the change in the percentage of forest from 1700 to 2018 has decreased atmospheric carbon dioxide concentrations. **Explain** whether the hypothesis is supported or refuted based on the data in the graph.

Urban environments have accounted for an increasing percentage of land use within the last few decades.

- (e) **Describe** a water-related environmental problem associated with urbanization.
- (f) **Describe** a potential response to mitigate the environmental problem identified in part (e).

Farmers who own large sections of cropland notice that bobcats, a medium-sized predatory forest cat, were present many years ago but are now virtually absent in the area. Instead, smaller mammal species now inhabit the area. Over time, the farmers have cleared nearly all of the forest on their property and converted it to farmland.



(g) **Explain** why there are fewer bobcats present on the farmland now compared to several decades ago.

The small mammal species are considered pests by the farmers. The farmers partner with a conservation group to increase the number of bobcats in the area. As a solution, the conservation group will introduce bobcats onto the few isolated patches of the original forested habitat left in the area. They can introduce only a small number of bobcats in each patch.

(h) **Describe** a disadvantage of introducing only a small population of bobcats.

(i) **Propose** a solution to improve the chances that the bobcat reintroductions will be successful in reestablishing wild populations.

(j) **Justify** the solution proposed in part (i) by describing an additional advantage, other than reestablishing the bobcat population near the farms.

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**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.**

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

- (a) **Describe** how TWO climate factors affect the rate of soil formation.
- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
  - (i) **Identify** one specific biotic component of the A horizon.
  - (ii) **Identify** one abiotic component of the A horizon.

Resources such as soil and water can be degraded by human activities.

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
  - (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
  - (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
  - (i) **Explain** one way acid deposition onto soil can affect plant health.
  - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

**STOP**

**END OF EXAM**

# 1 Biogeochemical cycles – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English        | 中文  | Write it 3 times (English) |
|----------------|-----|----------------------------|
| carbon cycle   | 碳循环 | _____                      |
| water cycle    | 水循环 | _____                      |
| nitrogen cycle | 氮循环 | _____                      |

## Recall

In Part A you followed energy through an ecosystem. Now follow the **matter**:

- Water evaporates, forms clouds, and falls as rain – the water cycle.
- Carbon moves between the air, living things, and the ground.
- Unlike energy, matter is **recycled** again and again.

Each idea has a short worked example before the Practice.

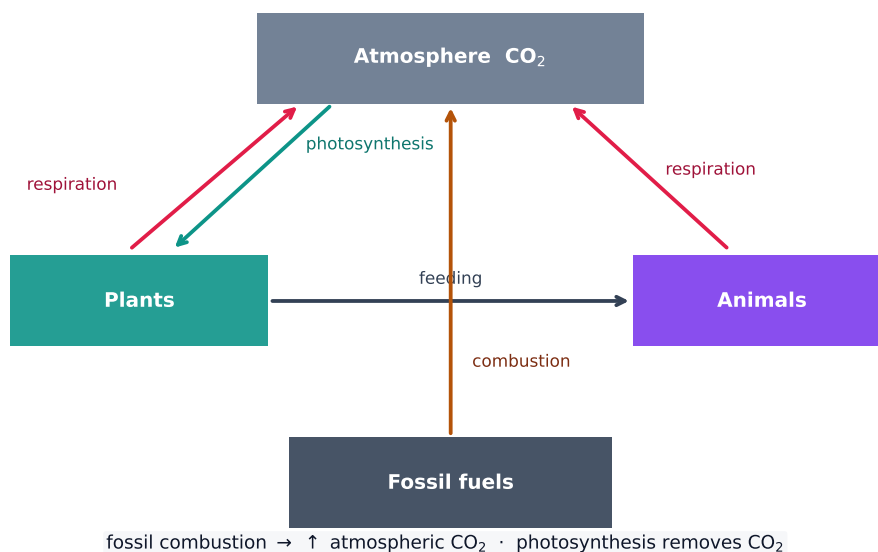
## New ideas

### ■ 1 Matter cycles, energy flows

Energy flows one way and is lost as heat, but **matter** (carbon, nitrogen, water) is used over and over – it **cycles** between living things and the environment.

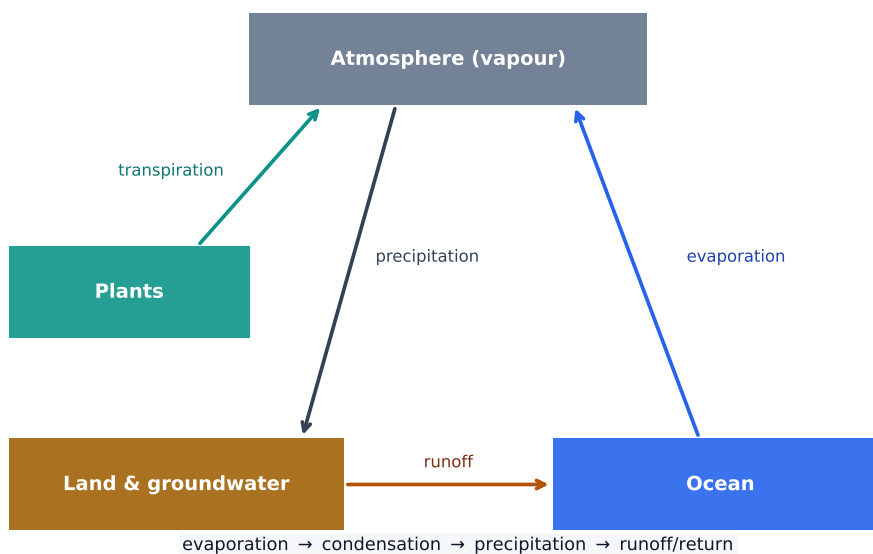
### ■ 2 The carbon cycle

In the **carbon cycle** 碳循环, carbon moves as CO<sub>2</sub>: taken from the air by photosynthesis, returned by respiration and by burning fuels.



### ■ 3 The water cycle

In the **water cycle** 水循环, water evaporates from oceans, condenses into clouds, falls as rain, and runs back to the sea.



### ■ 4 The nitrogen cycle

In the **nitrogen cycle** 氮循环, nitrogen from the air is turned into forms plants can use (by bacteria), passed along food chains, and returned to the air.

**Watch out:** energy and matter behave differently – energy **flows through** an ecosystem and is lost, but matter **cycles** and is reused. Burning fossil fuels adds extra carbon to the air, upsetting the natural carbon cycle.

## Practice

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Try these in order. The methods are all above.

**2.1** State the key difference between how energy and matter move through an ecosystem. [2]

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**2.2** State two processes that add carbon dioxide to the air, and one that removes it. [3]

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**2.3** List, in order, the main steps of the water cycle. [2]

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**2.4** State why plants cannot use nitrogen gas from the air directly. [1]

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**2.5** Explain how burning fossil fuels upsets the carbon cycle. [2]

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4. Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.
- (a) The atmosphere is one important carbon reservoir.
- (i) **Describe** a biological process by which carbon is removed from the atmosphere and converted to organic molecules.
  - (ii) **Describe** a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.
- (b) Oceans and terrestrial systems are also important carbon reservoirs.
- (i) **Explain** how atmospheric carbon is incorporated into two oceanic sinks.
  - (ii) **Identify** one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.
- (c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. **Discuss** TWO other human activities that increase the concentration of carbon in the atmosphere.
- (d) **Identify** an environmental problem that results from elevated atmospheric carbon concentrations. **Discuss** one consequence of the problem you identified.
- (e) Phosphorus is another element important to all organisms.
- (i) **Describe** one major way in which the phosphorus cycle differs from the carbon cycle.
  - (ii) **Identify** one reason that phosphorus is necessary for organisms.

**STOP**

**END OF EXAM**

**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."

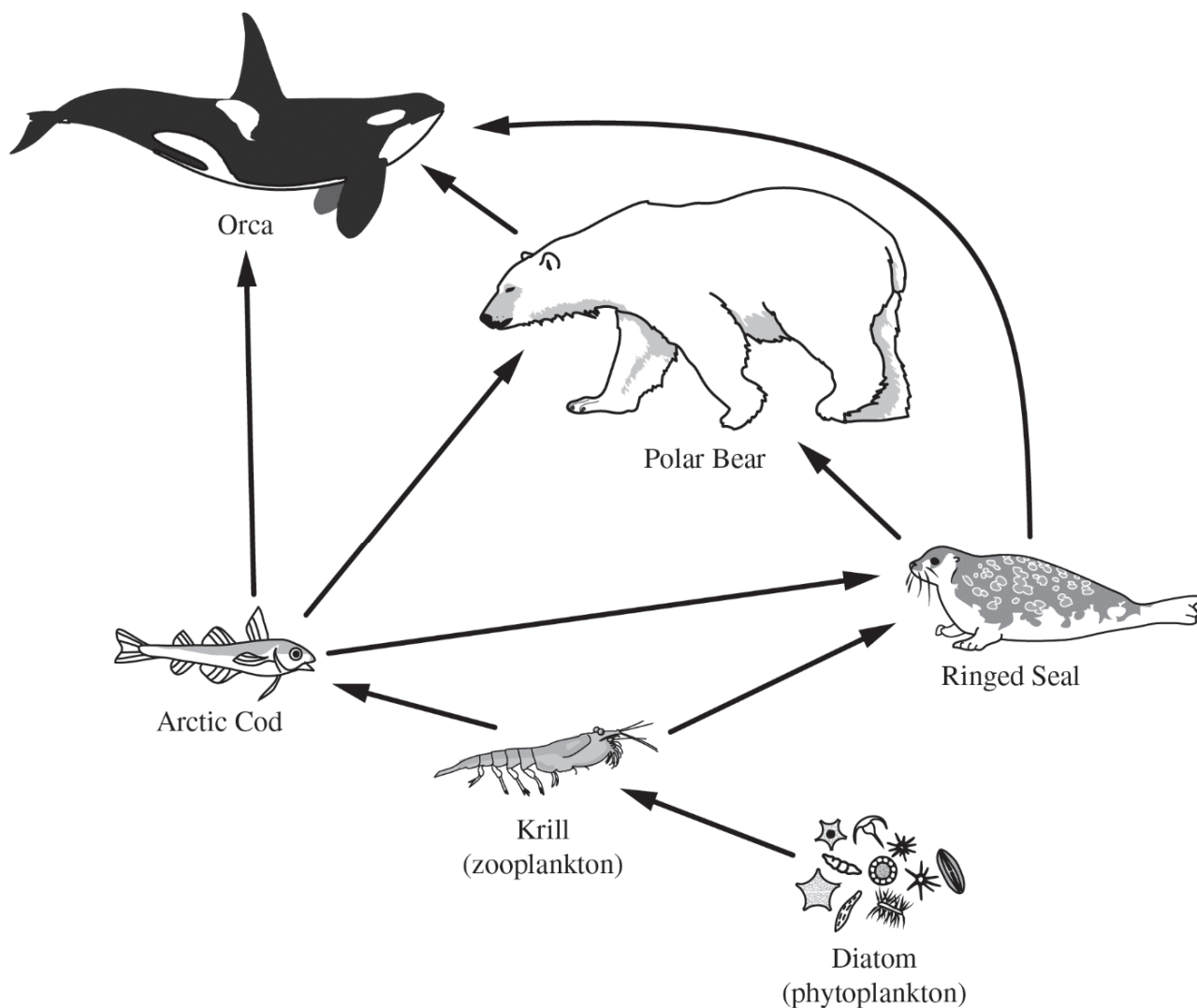
- (a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.
- (b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the 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.



3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

|                                            | Organism from Arctic food web |
|--------------------------------------------|-------------------------------|
| (i) <b>Identify</b> a primary producer     |                               |
| (ii) <b>Identify</b> a primary consumer    |                               |
| (iii) <b>Identify</b> a secondary consumer |                               |

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.
- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
  - (i) **Provide** one reason a species may migrate a long distance.
  - (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
  - (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

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## 2 Biodiversity and ecosystem services

### – Part 1

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

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*Write each word three times. 把每个单词抄写三遍。*

| English            | 中文     | Write it 3 times (English) |       |       |
|--------------------|--------|----------------------------|-------|-------|
| Biodiversity       | 生物多样性  | _____                      | _____ | _____ |
| species richness   | 物种丰富度  | _____                      | _____ | _____ |
| Ecosystem services | 生态系统服务 | _____                      | _____ | _____ |
| range of tolerance | 耐受范围   | _____                      | _____ | _____ |
| optimal range      | 最适范围   | _____                      | _____ | _____ |

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### Recall

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You already have a sense of nature's variety:

- Some places (like rainforests) have far more kinds of life than others (like deserts).
- Different animals and plants need different conditions to live.
- Nature gives us food, clean water, and clean air.

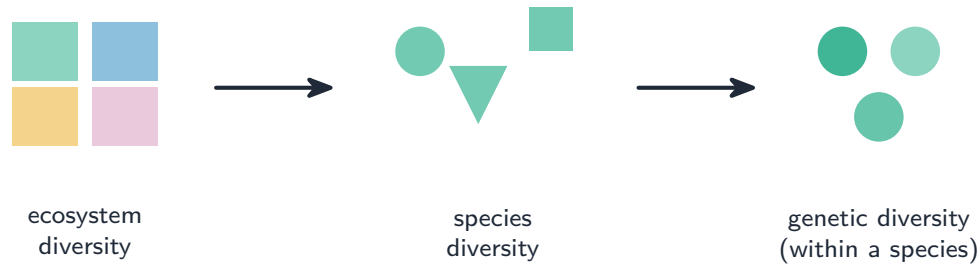
This sheet lines up how we describe and value that variety. Each idea has a short worked example.

### New ideas

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## ■ 1 Biodiversity

**Biodiversity** 生物多样性 is the variety of life, measured at three levels:



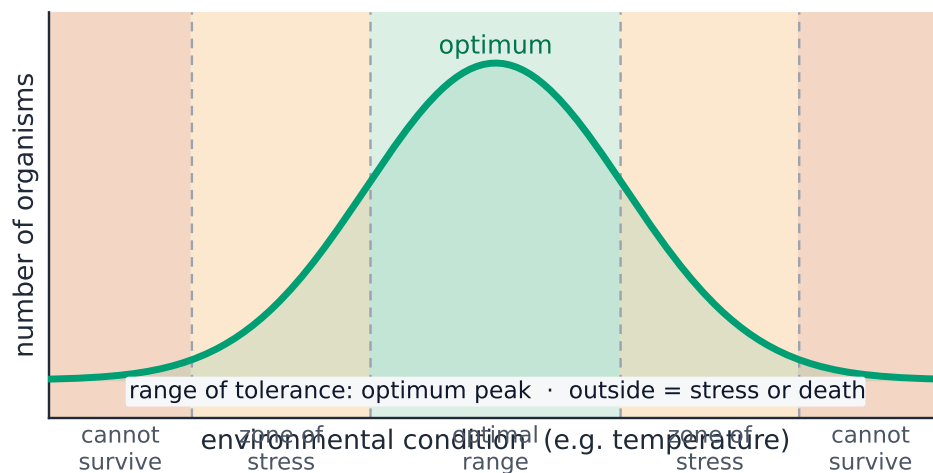
- **genetic** – variety of genes within a species,
- **species** – the number of different species (**species richness** 物种丰富度),
- **habitat** – the variety of habitats in a region.

## ■ 2 Ecosystem services

**Ecosystem services** 生态系统服务 are the free benefits nature gives people – food and water (provisioning), pollination and flood control (regulating), beauty and recreation (cultural), and nutrient cycling (supporting).

## ■ 3 Range of tolerance

Every species has a **range of tolerance** 耐受范围 – the span of conditions (temperature, pH, salinity) it can survive. Near the middle is an **optimal range** 最适范围 where it thrives; toward the edges it is stressed; beyond the limits it dies.



## ■ 4 Diversity and resilience

More species-rich ecosystems are more **resilient** – they recover from disruption more easily, because different species can fill roles when conditions change.

**Watch out:** **specialist** species (with narrow needs) are far more vulnerable than

**generalists** (which cope with many conditions). When a habitat changes, specialists disappear first.

## Practice

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Try these in order. The methods are all above.

**2.1** Name the three levels at which biodiversity is measured. [3]

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---

**2.2** Give one example each of a provisioning and a regulating ecosystem service. [2]

---

---

**2.3** State what the “optimal range” of a species is. [1]

---

**2.4** Explain why a species-rich ecosystem is usually more resilient. [2]

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**2.5** State whether a specialist or a generalist species is more at risk when its habitat changes, and why. [2]

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3. Habitat destruction and fragmentation can have many different effects on species.

- (a) **Describe** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird.
- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.
- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.
- (e) A male wood thrush needs a minimum of  $800 \text{ m}^2$  of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.
- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of  $1,100 \text{ m}^2$ . The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work.
- (g) **Calculate** the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **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**



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**STOP**

**END OF EXAM**

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

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

## 2 Succession and disturbance — Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English               | 中文   | Write it 3 times (English) |
|-----------------------|------|----------------------------|
| Ecological succession | 生态演替 | _____                      |
| primary succession    | 初级演替 | _____                      |
| secondary succession  | 次级演替 | _____                      |
| pioneer species       | 先锋物种 | _____                      |
| climax community      | 顶极群落 | _____                      |
| keystone species      | 关键种  | _____                      |
| indicator species     | 指示物种 | _____                      |

### Recall

In Part A you met biodiversity. Now see how ecosystems change and rebuild:

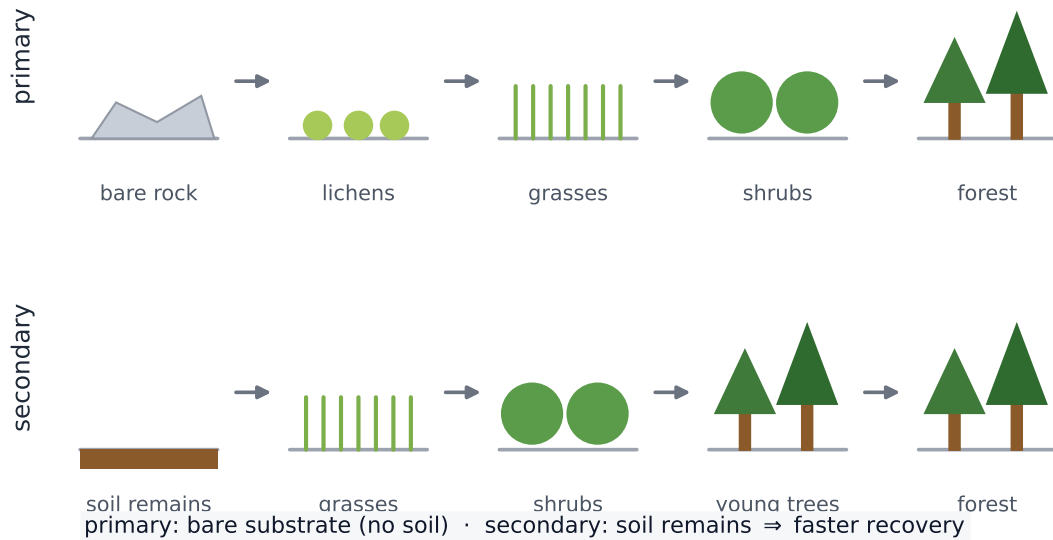
- After a fire or a landslide, plants slowly return.
- Some species matter far more to a community than their numbers suggest.

Each idea has a short worked example before the Practice.

### New ideas

## ■ 1 Ecological succession

**Ecological succession** 生态演替 is the gradual, orderly change in a community over time.



- **primary succession** 初级演替 starts on bare rock with **no soil** (after a glacier or lava) – very slow,
- **secondary succession** 次级演替 follows a disturbance that leaves the soil (after a fire or farming) – much faster.

## ■ 2 Pioneers to climax

The first arrivals, **pioneer species** 先锋物种 like lichens, slowly build soil. Over time the community develops toward a stable **climax community** 顶极群落.

## ■ 3 Keystone species

A **keystone species** 关键种 has an effect far larger than its numbers – remove it and the whole community can collapse (like sea otters that keep sea urchins in check).

## ■ 4 Indicator species

An **indicator species** 指示物种 signals the health of an ecosystem by its presence or absence – lichens vanish where the air is polluted.

**Watch out:** primary succession is much **slower** than secondary succession, because it must first build soil from bare rock, while secondary succession already has soil to start from.

## Practice

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Try these in order. The methods are all above.

**2.1** State the difference between primary and secondary succession. [2]

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**2.2** Explain why primary succession is slower than secondary succession. [2]

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**2.3** Name a typical pioneer species and state what it does. [2]

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**2.4** State what a keystone species is. [2]

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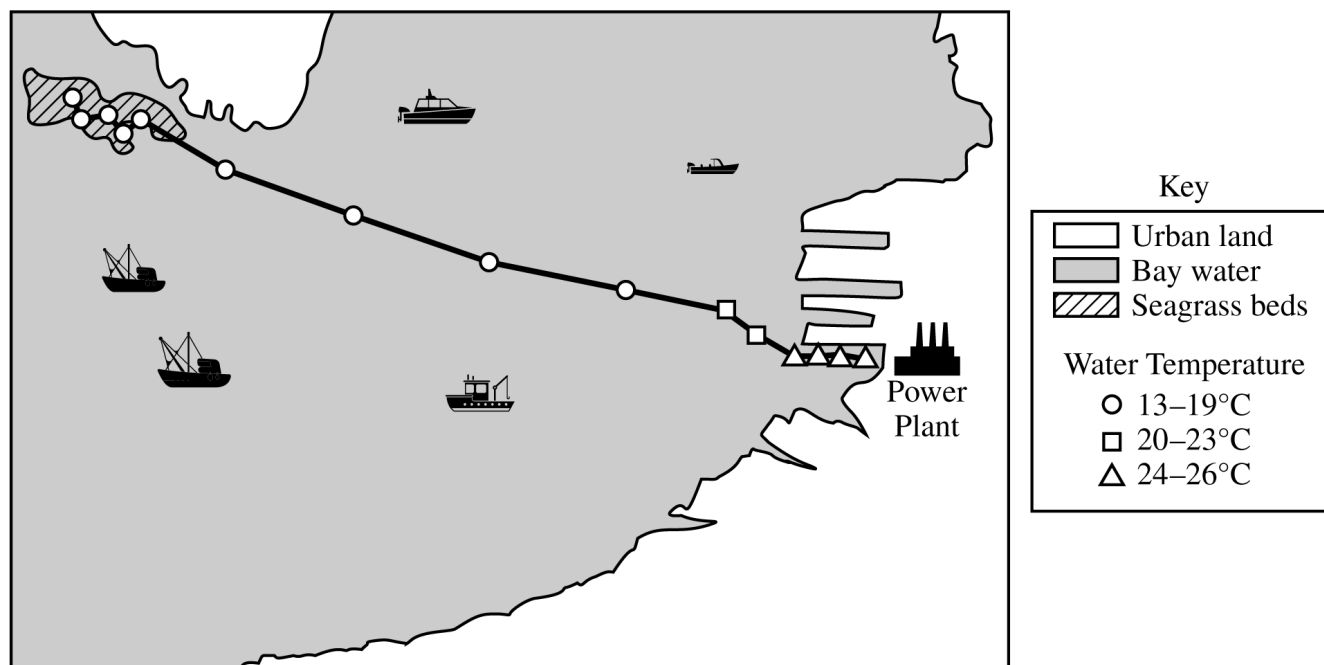
**2.5** Explain how an indicator species can show that an ecosystem is polluted. [2]

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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.
- 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.

(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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**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.**

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

- A. **Describe** one reproductive strategy used by a K-selected species such as the chickadee.
- B. Based on the information provided, **explain** how a decrease in spider populations could affect a lower trophic level.
- C. Based on the data in Figure 1, **identify** the number of spiders per sample at 25% nonnative plants.
- D. Based on the data in Figure 1, **describe** the trend in the number of insects per sample in relation to the percentage of nonnative plants.
- E. Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. **Describe** one way that the data in Figure 2 support this hypothesis.
- F. Insect biodiversity is important to maintain ecosystem health. A group of students was interested in learning about factors that affect ant biodiversity. They located two study sites near their school: a frequently mowed urban park and an unmowed grassland. The students used traps designed to collect ants. They loaded 10 of these traps with the same food and placed them randomly at different locations within each site. Students collected the traps after 24 hours and counted the number of different ant species in each trap to determine species richness.
- Identify** a likely scientific question for the students' investigation of ant diversity.
  - Identify** the dependent variable in the students' investigation.
- G. The data from the student investigation of ant diversity are shown in the following table. An "X" in the table indicates that the species was present at that site.

Ant Species Present in an Urban Park and Unmowed Grassland

| Site       | Species A | Species B | Species C | Species D | Species E | Species F |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Urban park | X         |           |           | X         | X         |           |
| Grassland  | X         | X         | X         | X         |           | X         |

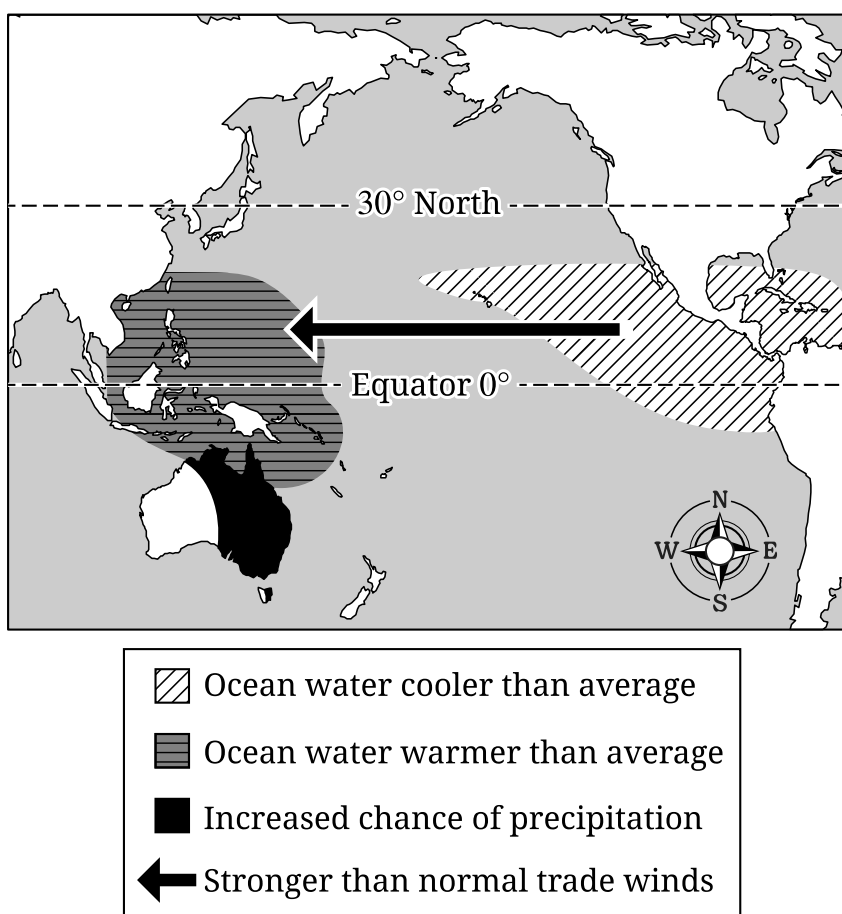
- Explain** why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would.
  - Explain** how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland.
- H. Habitat fragmentation has impacts on a variety of species. Paved roads can lead to habitat fragmentation.
- Describe** one effect that a paved road in a forest can have on animal species such as deer or bears.

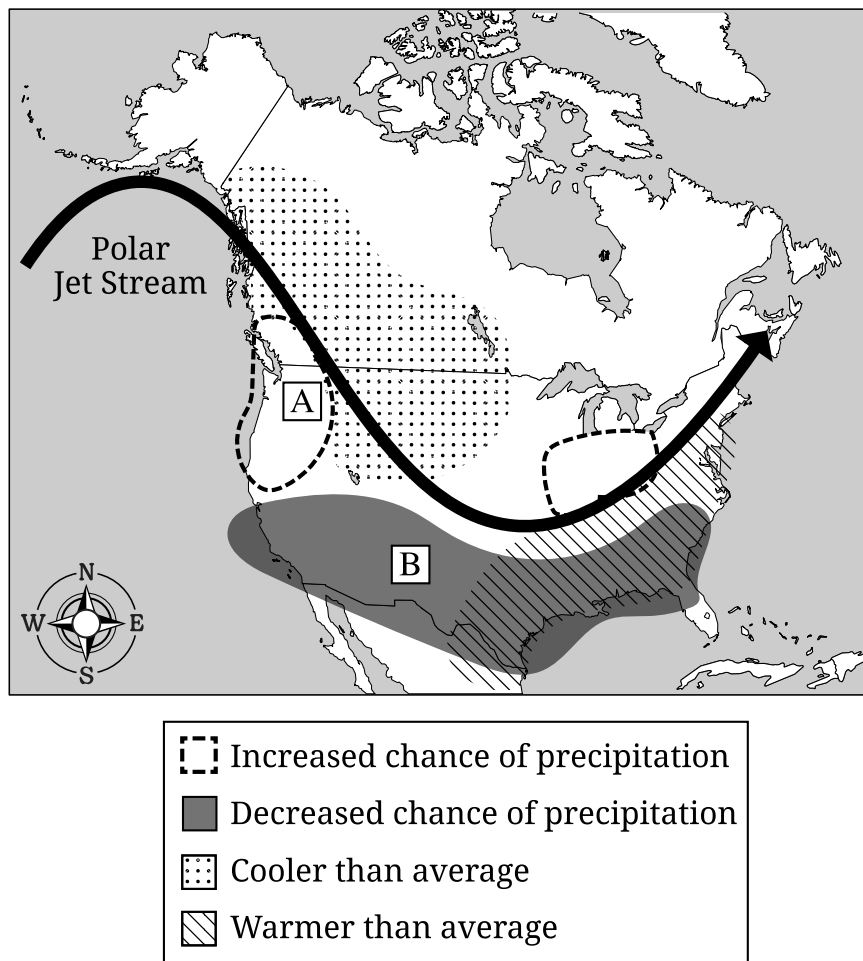


There is a natural climate phenomenon that occurs in the equatorial Pacific Ocean because of periodic fluctuations in sea surface conditions and atmospheric circulation. This phenomenon happens every few years, resulting in shifts in temperature and precipitation in many parts of the world.

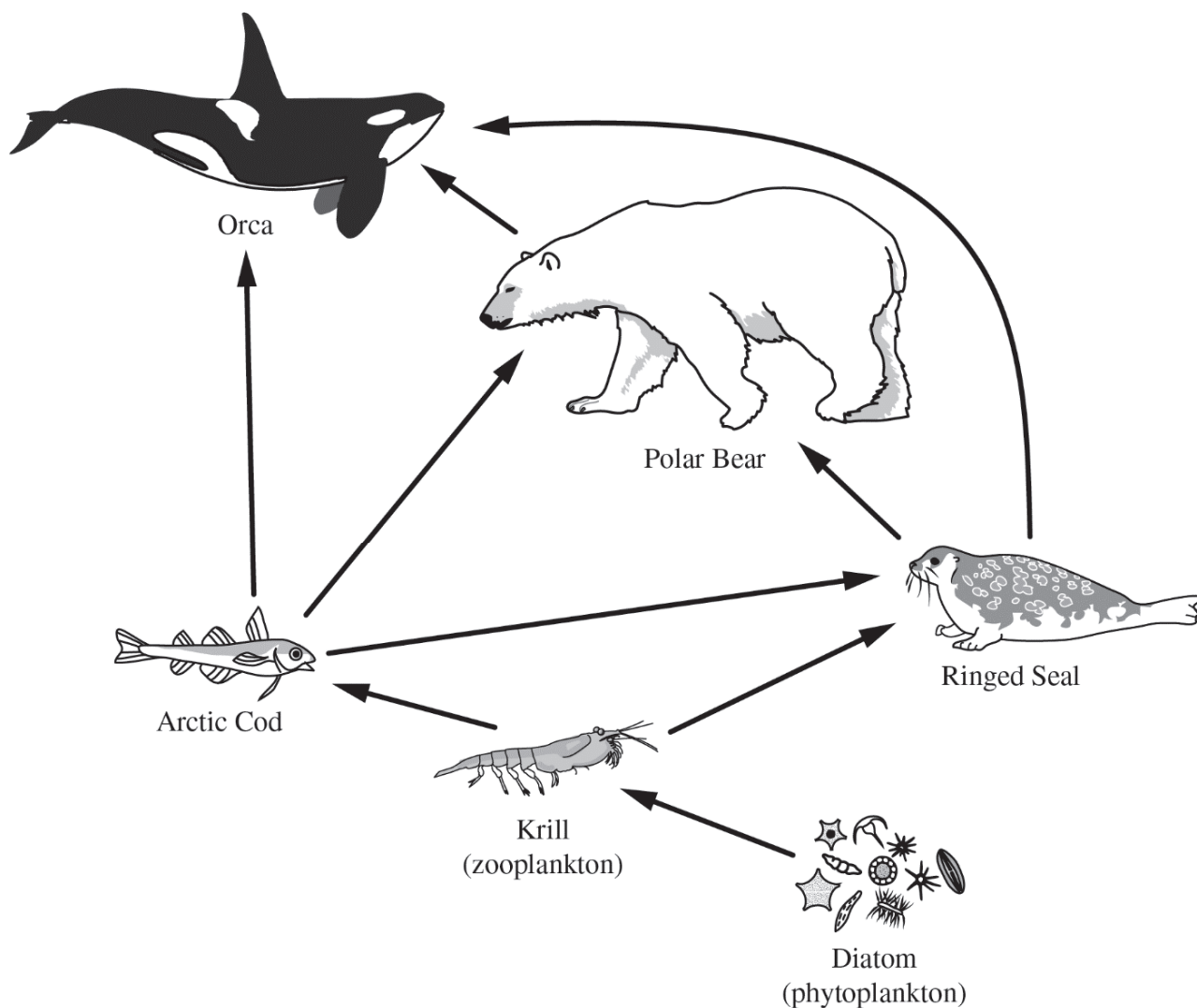
Figure 1 shows temperature and precipitation patterns associated with one phase of this phenomenon in the equatorial Pacific Ocean. Figure 2 shows the associated temperature and precipitation patterns that occur over North America.

**Figure 1. Effects of Changes in Sea Surface Conditions in Equatorial Pacific Ocean**



**Figure 2. Polar Jet Stream and Climate Conditions in North America**

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

|                                            | Organism from Arctic food web |
|--------------------------------------------|-------------------------------|
| (i) <b>Identify</b> a primary producer     |                               |
| (ii) <b>Identify</b> a primary consumer    |                               |
| (iii) <b>Identify</b> a secondary consumer |                               |

(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.
- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
  - (i) **Provide** one reason a species may migrate a long distance.
  - (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
  - (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

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

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.



# 3 Species strategies and population growth

## – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English           | 中文    | Write it 3 times (English) |
|-------------------|-------|----------------------------|
| generalist        | 广适性物种 | _____                      |
| specialist        | 狭适性物种 | _____                      |
| carrying capacity | 环境容纳量 | _____                      |

### Recall

You already know that populations of animals and plants change over time:

- A population can grow when food and space are plentiful.
- It cannot grow forever – something eventually limits it.
- Some animals have many young; others have just a few.

This sheet lines up how populations grow. Each idea has a short worked example.

### New ideas

#### ■ 1 Generalists and specialists

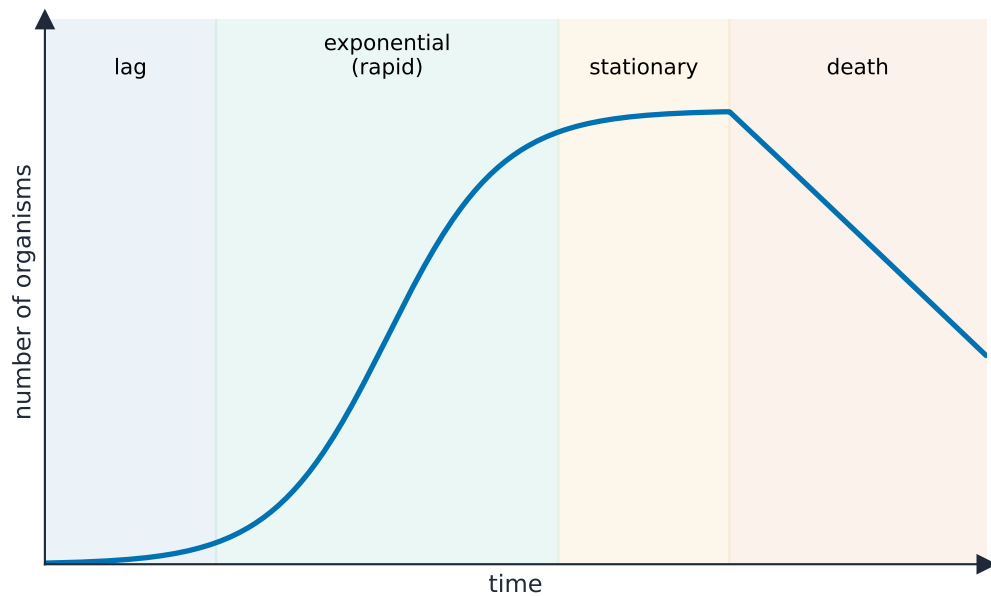
A **generalist** 广适性物种 can live in many places and eat many foods (a raccoon), so it copes well with change. A **specialist** 狭适性物种 needs specific conditions (a panda), so it is efficient but vulnerable if its habitat changes.

#### ■ 2 Two reproductive strategies

- ***r*-selected** species have **many** offspring with little care (insects, weeds) – fast to grow, boom and bust.
- ***K*-selected** species have **few** offspring with much care (elephants, humans) – slow to recover from losses.

### ■ 3 Population growth

With plenty of resources a population grows **exponentially** (a J-shape). As resources run short, growth slows to a levelling **S-shape** at the **carrying capacity** 环境容纳量 – the most the environment can support.



### ■ 4 Limiting factors

Food, water, space, disease, and predators are **limiting factors** that stop a population growing without end.

**Watch out:** a population can briefly **overshoot** its carrying capacity when resources are temporarily plentiful, then **crash** as those resources run out. Growth is not always smooth.



## Practice

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Try these in order. The methods are all above.

**2.1** State the difference between a generalist and a specialist species. [2]

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**2.2** State one feature of an  $r$ -selected species and one of a  $K$ -selected species. [2]

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**2.3** State what “carrying capacity” means. [2]

---

---

**2.4** Name three factors that can limit a population’s size. [2]

---

---

**2.5** Explain what happens when a population overshoots its carrying capacity. [2]

---

---

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

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

**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."

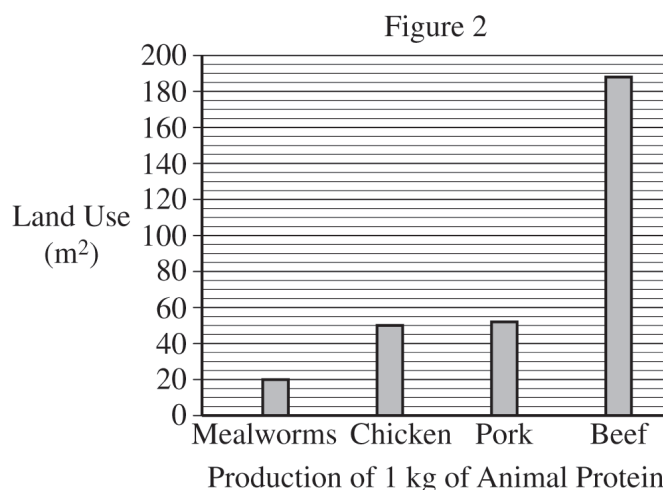
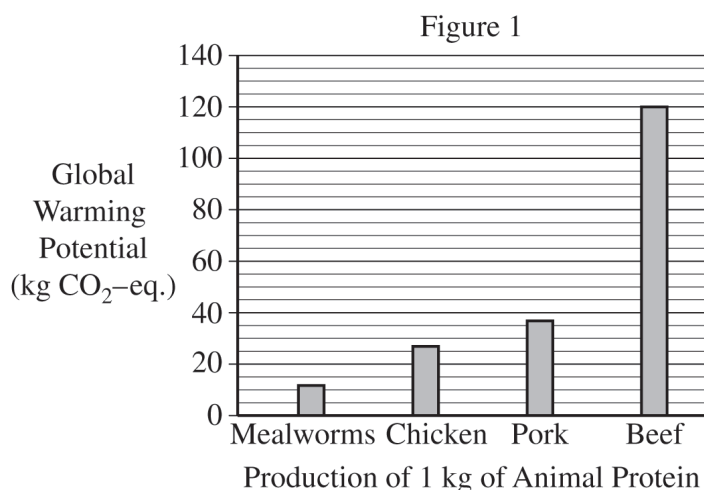
- (a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.
- (b) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the 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.

2. As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent ( $\text{kg CO}_2\text{-eq.}$ ). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared ( $\text{m}^2$ ).

## Global Warming Potential and Land Use from Animal Protein Production



- (a) Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein.

Mealworms, the larvae of the darkling beetle, consume grains and decaying plant material. Darkling beetles are an *r*-selected species, and the entire mealworm can be consumed by humans for protein.

- (b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle.

- (c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population.

An individual's diet choices affect greenhouse gas emissions and land use.

- (d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage.

Cattle emit methane from fermentation in their digestive systems. The other animals do not emit methane.

- (e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have.

Agricultural practices can have negative impacts on rivers and streams.

- (f) **Describe** how water quality can be altered by cattle grazing that occurs near a stream or river.
- (g) **Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze.
- (h) Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion.
- (i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion.
- (j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change.

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**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 Human populations – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English               | 中文    | Write it 3 times (English) |
|-----------------------|-------|----------------------------|
| age-structure diagram | 年龄结构图 | _____                      |
| total fertility rate  | 总生育率  | _____                      |

### Recall

The human population has grown very fast, but not evenly everywhere:

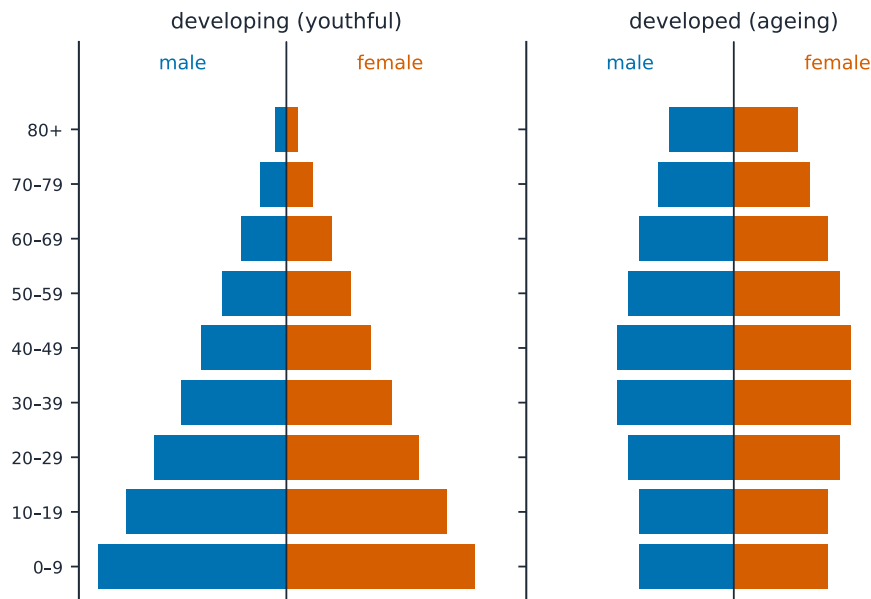
- Some countries have many young people; others have an ageing population.
- Birth rates are higher in some countries than others.

Each idea has a short worked example before the Practice.

### New ideas

#### ■ 1 Age-structure diagrams

An **age-structure diagram** 年龄结构图 shows how many people are in each age group. A **wide base** (many children) predicts rapid growth; even bars predict a stable population.



## ■ 2 Total fertility rate

The **total fertility rate** 总生育率 (TFR) is the average number of children per woman. A **replacement level** of about 2.1 keeps a population steady; above it grows, below it shrinks.

## ■ 3 Doubling time (rule of 70)

A population's doubling time is found from the **rule of 70**: divide 70 by the growth rate (as a percent).

*Worked example.* A country grows at 2.0% per year, so it doubles in about  $\frac{70}{2.0} = 35$  years. At 3.5% it would double in only 20 years.

## ■ 4 The demographic transition

As a country develops, its growth changes in stages: (1) high birth and death rates, (2) death rate falls (fast growth), (3) birth rate falls (slowing), (4) both low (stable).

**Watch out:** a falling **growth rate** does not mean the population is shrinking – it is still growing, just more slowly. The population only shrinks when births fall below deaths.



## Practice

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Try these in order. The methods are all above.

**2.1** State what a wide-based age-structure diagram tells you about a population. [1]

---

**2.2** State the replacement-level total fertility rate and what it means. [2]

---

---

**2.3** A population grows at 1.4% per year. Use the rule of 70 to find its doubling time. [2]

**2.4** A population grows at 5.0% per year. Find its doubling time. [2]

**2.5** Name two factors that tend to lower a country's birth rate as it develops. [2]

---

---

3. Habitat destruction and fragmentation can have many different effects on species.

- (a) **Describe** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird.
- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.
- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.
- (e) A male wood thrush needs a minimum of  $800 \text{ m}^2$  of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.
- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of  $1,100 \text{ m}^2$ . The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work.
- (g) **Calculate** the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **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**

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

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

3. Haiti shares a border with the Dominican Republic on the Caribbean island of Hispaniola.
- (a) The border between the two countries can be seen using satellite images because of the severe deforestation in Haiti.
    - (i) **Provide** one reason why deforestation commonly occurs in a less developed country such as Haiti.
    - (ii) **Describe** one realistic strategy to reduce deforestation in a less developed country.
  - (b) Deforestation can affect water quality. **Identify** one change that can occur in the water quality of streams within a watershed that has been deforested. **Explain** how deforestation can lead to this change.
  - (c) **Identify** TWO environmental benefits, other than those related to water quality, of maintaining forest ecosystems.

The table below contains demographic data for Haiti in 1995 and 2015.

DEMOGRAPHIC DATA FOR HAITI

| Measure                                       | 1995 | 2015 |
|-----------------------------------------------|------|------|
| Fertility rate (number of children per woman) | 5.2  | 2.7  |
| Life expectancy (years)                       | 55   | 64   |
| Infant mortality (deaths per 1,000)           | 85   | 48   |

- (d) **Identify** and **discuss** one factor in a less developed country that could contribute significantly to a change in life expectancy, similar to what occurred in Haiti from 1995 to 2015.
- (e) **Identify** and **discuss** one economic or cultural factor in a less developed country that could contribute significantly to a change in the fertility rate, similar to what occurred in Haiti from 1995 to 2015.

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. **Identify** a type of surface mining the company could use to access the coal.

B. **Describe** an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

**Describe** an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

**Propose** a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses  $1.064 \times 10^4$  kWh of electricity each year.

**Calculate** how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

**Calculate** the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

**STOP**

**END OF EXAM**



# 4 Rocks, soil, and the atmosphere — Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English         | 中文   | Write it 3 times (English) |       |       |
|-----------------|------|----------------------------|-------|-------|
| plates          | 板块   | _____                      | _____ | _____ |
| plate tectonics | 板块构造 | _____                      | _____ | _____ |
| Soil            | 土壤   | _____                      | _____ | _____ |
| weathers        | 风化   | _____                      | _____ | _____ |
| Erosion         | 侵蚀   | _____                      | _____ | _____ |
| texture         | 质地   | _____                      | _____ | _____ |
| atmosphere      | 大气层  | _____                      | _____ | _____ |
| troposphere     | 对流层  | _____                      | _____ | _____ |
| stratosphere    | 平流层  | _____                      | _____ | _____ |

## Recall

You already know some earth science:

- Earthquakes and volcanoes happen where Earth's surface is active.
- Soil grows plants, and it can be washed or blown away.
- Air is mostly nitrogen and oxygen.

This sheet lines up Earth's rocks, soil, and air. Each idea has a short worked example.

## New ideas

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### ■ 1 Plate tectonics

Earth's crust is broken into **plates** 板块 that slowly move – **plate tectonics** 板块构造. Where they pull apart, collide, or slide past, you get earthquakes, volcanoes, and mountains.

### ■ 2 Soil and erosion

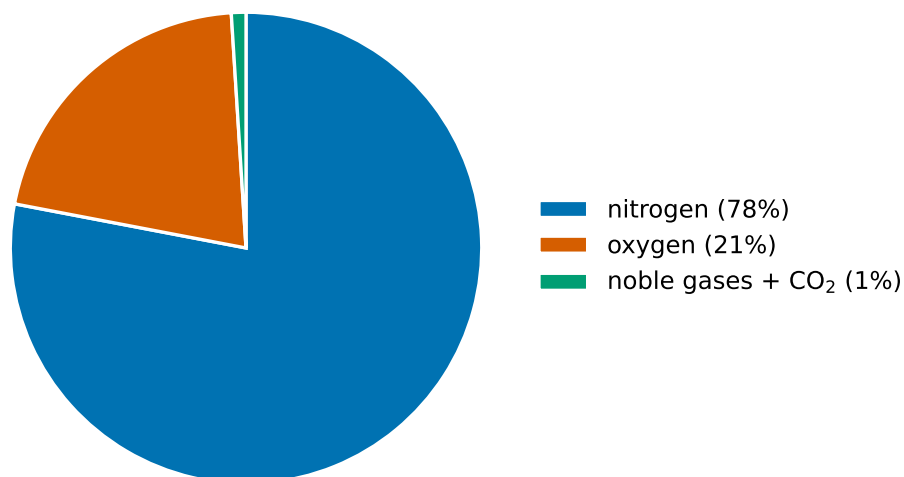
**Soil** 土壤 forms slowly as rock **weathers** 风化 and dead matter builds up. **Erosion** 侵蚀 is the removal of soil by wind and water, sped up when plants are removed (farming, deforestation).

### ■ 3 Soil texture

Soil is a mix of sand, silt, and clay – its **texture** 质地 – plus water and air. Texture controls how well soil holds water and nutrients; a balanced mix (loam) is best for plants.

### ■ 4 The atmosphere

The **atmosphere** 大气层 is layered: the **troposphere** 对流层 (where weather happens) and the **stratosphere** 平流层 (holding the ozone layer). It is about 78% nitrogen and 21% oxygen.



**Watch out:** soil forms extremely slowly (centimetres over centuries). If erosion removes it faster than it forms, the land loses a vital resource that cannot be quickly replaced.



## Practice

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Try these in order. The methods are all above.

**2.1** Name two things that happen where Earth's plates meet. [2]

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**2.2** State the difference between weathering and erosion. [2]

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**2.3** Name the three particle types that make up soil texture. [1]

---

**2.4** Name the two main gases in the atmosphere and their approximate percentages. [2]

---

---

**2.5** Explain why soil erosion is such a serious problem. [2]

---

---

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

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.
- (a) **Describe** how TWO climate factors affect the rate of soil formation.
  - (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
    - (i) **Identify** one specific biotic component of the A horizon.
    - (ii) **Identify** one abiotic component of the A horizon.

Resources such as soil and water can be degraded by human activities.

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
  - (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
  - (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
  - (i) **Explain** one way acid deposition onto soil can affect plant health.
  - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

**STOP**

**END OF EXAM**

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**STOP**

**END OF EXAM**

## 4 Weather and climate – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English              | 中文     | Write it 3 times (English) |       |       |
|----------------------|--------|----------------------------|-------|-------|
| global wind patterns | 全球风带   | _____                      | _____ | _____ |
| Coriolis effect      | 科里奥利效应 | _____                      | _____ | _____ |
| watershed            | 流域     | _____                      | _____ | _____ |
| rain shadow          | 雨影     | _____                      | _____ | _____ |
| El Niño              | 厄尔尼诺   | _____                      | _____ | _____ |
| La Niña              | 拉尼娜    | _____                      | _____ | _____ |

### Recall

You already notice weather and seasons:

- The Sun heats the equator more than the poles.
- Winds blow in fairly steady directions.
- Summer and winter come and go through the year.

This sheet lines up what drives weather and climate. Each idea has a short worked example.

### New ideas

## ■ 1 Global winds

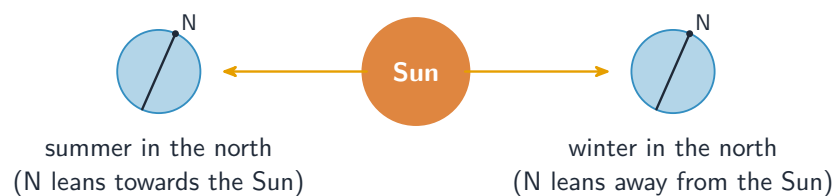
The Sun heats Earth unevenly, so warm air rises at the equator and sinks near the tropics, creating **global wind patterns** 全球风带. The spinning Earth bends these winds – the **Coriolis effect** 科里奥利效应.

## ■ 2 Watersheds

A **watershed** 流域 is all the land that drains into a shared body of water. Whatever happens on that land – farming, paving, pollution – ends up in the water it drains into.

## ■ 3 Seasons come from the tilt

**Seasons** come from Earth's **tilted axis** (about  $23.5^\circ$ ), not its distance from the Sun. The hemisphere tilted **toward** the Sun gets more direct light and longer days – summer.



## ■ 4 Climate patterns

Geography shapes climate: latitude, height, and nearness to oceans. Mountains create a **rain shadow** 雨影 (wet on the windward side, dry on the leeward side). **El Niño** 厄尔尼诺 and **La Niña** 拉尼娜 are shifts in Pacific temperatures that change rainfall worldwide.

**Watch out:** seasons are caused by the Earth's **tilt**, not by how close it is to the Sun. In fact the Earth is slightly closer to the Sun during the northern winter.

## Practice

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Try these in order. The methods are all above.

**2.1** State what causes global wind patterns. [2]

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**2.2** State what a watershed is. [2]

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**2.3** Explain what really causes the seasons. [2]

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**2.4** Explain why one side of a mountain range is much drier than the other (a rain shadow). [2]

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**2.5** State what El Niño and La Niña are. [1]

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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.

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**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. Increasing global urbanization causes associated problems such as the formation of urban heat islands.

(a) **Describe** how urbanization leads to the formation of urban heat islands.

(b) Urban heat islands have been linked to a variety of environmental problems.

(i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands.

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands.

(c) Urban areas are increasingly using solar energy to generate electricity for residences and businesses.

(i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from \$0.11 per kWh to \$0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work.

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work.

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August.

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**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. Respond to parts A, B, C, D, E, F, G, H, I, and J.

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

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# 5 Using the land – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English                | 中文   | Write it 3 times (English) |
|------------------------|------|----------------------------|
| tragedy of the commons | 公地悲剧 | _____                      |
| green revolution       | 绿色革命 | _____                      |
| Irrigation             | 灌溉   | _____                      |
| Deforestation          | 森林砍伐 | _____                      |

## Recall

You already know that people use the land in many ways:

- Farms grow the food we eat.
- Forests are cut down for wood and to clear land.
- Shared resources, like fish in the sea, can be used up.

This sheet lines up how we use the land. Each idea has a short worked example.

## New ideas

### ■ 1 The tragedy of the commons

When a resource is shared by everyone and owned by no one, each person takes as much as they can, and it gets overused – the **tragedy of the commons** 公地悲剧 (like overfishing a shared sea).

## ■ 2 The green revolution

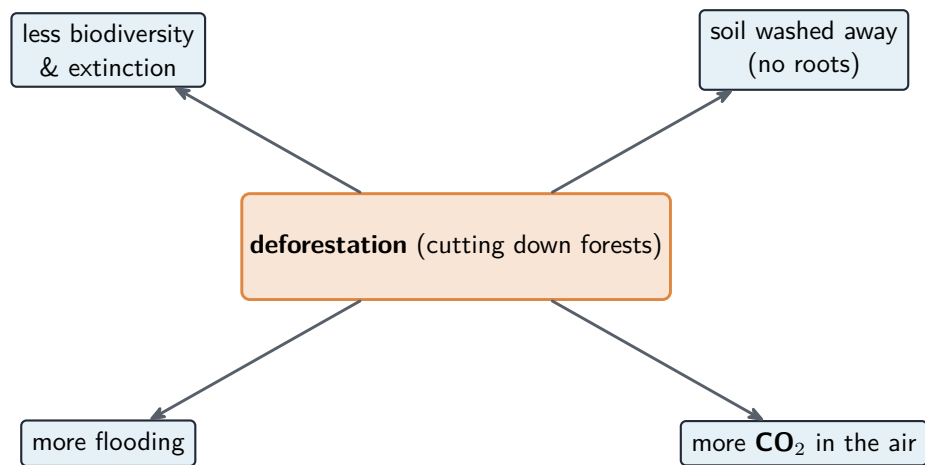
The **green revolution** 绿色革命 raised crop yields with modern methods – fertilizers, irrigation, machines, and improved seeds – but these bring costs like pollution and heavy water use.

## ■ 3 Irrigation

**Irrigation** 灌溉 supplies water to crops. It boosts harvests but can drain rivers and aquifers, and can leave salt behind in the soil (salinization).

## ■ 4 Deforestation

**Deforestation** 森林砍伐 (clearing forests) removes habitat, causes soil erosion and flooding, and releases stored carbon dioxide.



**Watch out:** the tragedy of the commons happens because **no single person owns** the resource, so each gains from taking more while everyone shares the cost of overuse. Clear rules or ownership can prevent it.

## Practice

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Try these in order. The methods are all above.

**2.1** Explain what the “tragedy of the commons” is, with an example. [2]

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**2.2** State one benefit and one cost of the green revolution. [2]

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**2.3** State one problem that irrigation can cause. [1]

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**2.4** List three harmful effects of deforestation. [3]

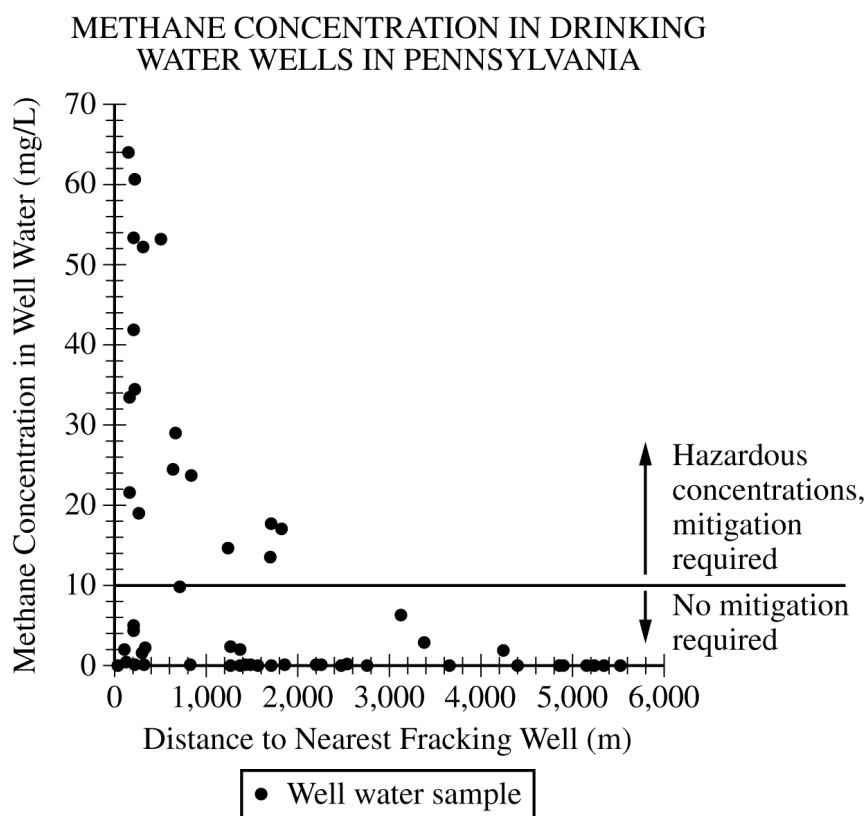
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**2.5** Suggest one way to prevent the overuse of a shared resource. [1]

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



- (a) The graph shows the methane concentration in drinking water from home wells and the distance to the nearest fracking well in Pennsylvania.
- Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania.
  - Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well.
  - Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well.
  - Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process.
  - Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.
- (b) The volume of water used for oil and gas extraction is 28 times greater than it was fifteen years ago. Much of the water used for oil and gas extraction comes from groundwater sources in arid or semiarid regions. This increased use of water for fracking may mean that less water is available for local use.
- The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource.
  - Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions.
  - Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption.



- (c) In addition to water quality issues caused by fossil fuel extraction, air quality can also be negatively affected by combustion of oil and natural gas.
- (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil.
  - (ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change.

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**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. Habitat destruction and fragmentation can have many different effects on species.

- (a) **Describe** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird.
- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.
- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.
- (e) A male wood thrush needs a minimum of  $800 \text{ m}^2$  of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.
- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of  $1,100 \text{ m}^2$ . The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work.
- (g) **Calculate** the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **Show** your work.

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**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**

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

- (a) **Describe** how TWO climate factors affect the rate of soil formation.
- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
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Resources such as soil and water can be degraded by human activities.

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
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**STOP**

**END OF EXAM**

## 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 interested in sustainability developed three new varieties of genetically modified green beans designed to produce higher yields in arid regions. Four plots (A–D) were set up on a floodplain of a river to grow beans. Plots A, B, and C were each planted with seeds of different types of genetically modified strains of green beans. Plot D was planted with seeds of unmodified green beans. Each plot was given equal amounts of fertilizer, which contains phosphorus and nitrogen, and water and was irrigated using spray irrigation for one hour per day. Throughout the growing season, researchers measured the amount of green beans harvested within each plot. The plots with genetically modified beans had higher crop yields than the plot with unmodified beans.

- (a) **Identify** the control group in this experiment.
- (b) **Identify** the scientific question for the investigation.
- (c) Researchers repeated the experiment by modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification.

Researchers also monitored the amount of sediment and fertilizer washing into the river from each plot in the original study. The soil temperature was also measured in each plot at the same depth and at the same time each day approximately 0.05 meters below the surface of the soil.

**Genetically Modified Green Bean Experimental Results**

| Plot                 | Sediment Runoff<br>(mg/L) | Phosphorus Runoff<br>(mg/L) | Nitrogen Runoff<br>(mg/L) | Soil Temperature<br>(°C) |
|----------------------|---------------------------|-----------------------------|---------------------------|--------------------------|
| A (Type 1 GMO beans) | 2.4                       | 0.11                        | 1.07                      | 18.6                     |
| B (Type 2 GMO beans) | 2.1                       | 0.02                        | 0.56                      | 18.3                     |
| C (Type 3 GMO beans) | 0.9                       | 0.04                        | 0.68                      | 18.3                     |
| D (Unmodified beans) | 3.5                       | 0.15                        | 1.24                      | 17.6                     |

- (d) Based on the data in the table, **identify** the plot with the lowest soil temperature.
- (e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans.

- (f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted.

Once the experiment was concluded, the researchers burned the plots to remove the crops that had been planted. After a few years, the researchers returned to the plots and observed a variety of plants, insects, and bird species living there.

- (g) **Describe** the ecological process that occurred on the plots after the crops were burned.

A survey indicated that one of the plots had twice the plant diversity that the other plots had. Over the next five years, the river occasionally flooded the plots, killing off many of the species that inhabited the plots.

- (h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding.
- (i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could.
- (j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot.

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**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. Respond to parts A, B, C, D, E, F, G, H, I, and J.**

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

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.

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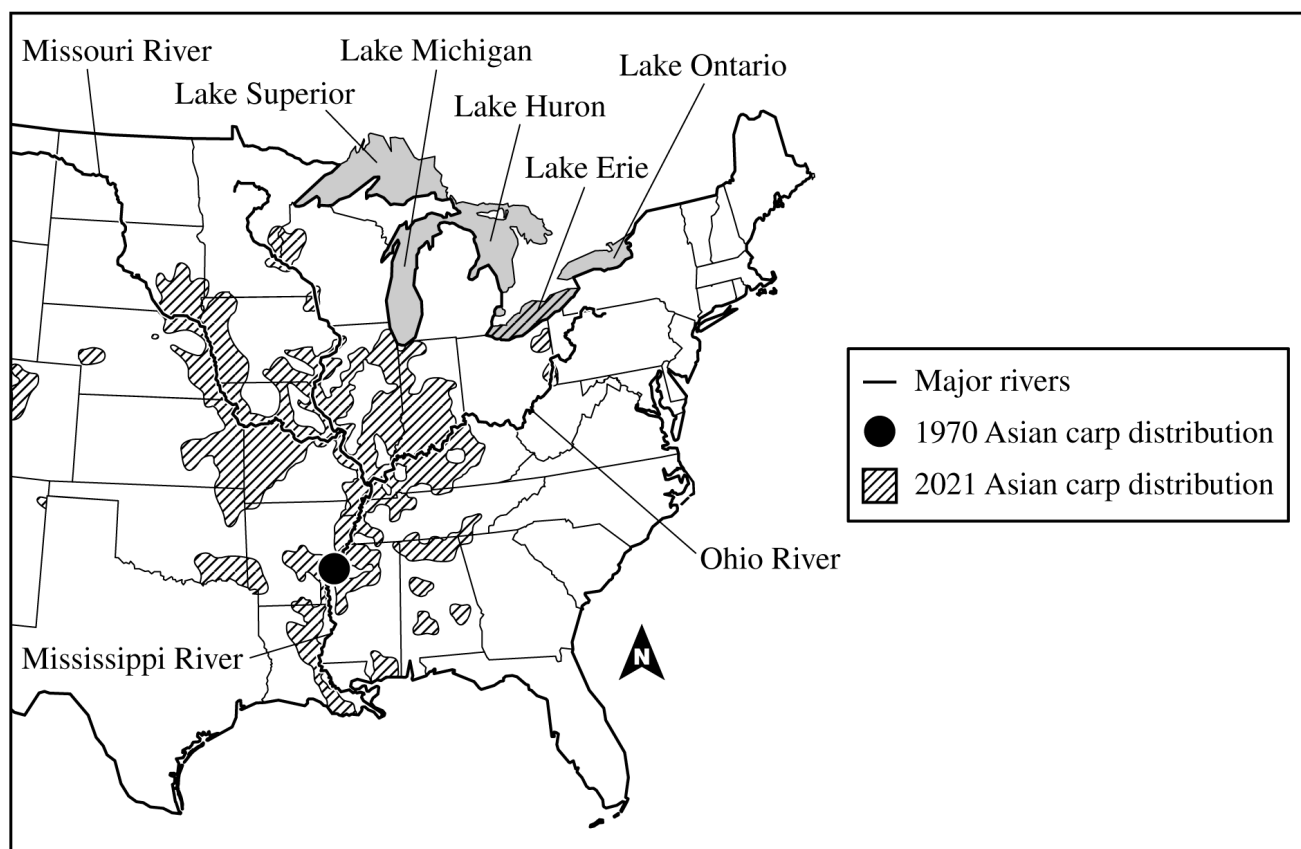
**Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.**

**STOP**

**END OF EXAM**

2. Asian carp were first introduced in the southern United States in the 1970s by fish farmers wanting to control algal growth in fish ponds. Asian carp can eat up to 40% of their body weight in algae each day, and a female carp can produce up to 1 million eggs every year.

## Distribution of the Asian Carp in the United States



- (a) Based on the information given, **identify** a body of water invaded by Asian carp that is labeled on the map.
- (b) Based on the information shown in the map, **describe** the change in the distribution of Asian carp since their introduction in the 1970s.

The Great Lakes are a group of five major freshwater inland lakes that all share the same watershed.

- (c) **Describe** one impact the introduction of Asian carp could have on the ecosystem services provided by the Great Lakes region.
- (d) **Propose** a realistic solution to help reduce the spread of the Asian carp from their current distribution.
- (e) **Justify** the solution proposed in part (d) by providing an additional advantage.

The following is an example of a simple food chain in the Great Lakes.

Algae → Zooplankton → Macroinvertebrates → Yellow perch → Rainbow trout

- (f) **Identify** the primary consumer in the Great Lakes food chain.
- (g) **Describe** what the arrows in the aquatic food chain represent.



(h) **Describe** one possible effect of the introduction of the Asian carp on the Great Lakes food chain.

The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(i) **Describe** one way that overfishing of blue pike illustrates the tragedy of the commons.

(j) One potential solution to reduce overfishing is to use aquaculture. **Describe** one disadvantage of this solution.

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2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

| Global Iron and Steel Data                                     |
|----------------------------------------------------------------|
| 1.6 billion tons of iron ore are used yearly to make pig iron. |
| 1.2 billion tons of pig iron are produced each year.           |
| Iron ore reserves are estimated to be 800 billion tons.        |
| 95% of iron ore that is mined is used in steel production.     |

- (i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.
- (ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.
- (iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

- (b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

- (c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.
- (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).
- (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

## 5 Impacts and sustainability – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English                   | 中文   | Write it 3 times (English) |
|---------------------------|------|----------------------------|
| Overfishing               | 过度捕捞 | _____                      |
| Urbanization              | 城市化  | _____                      |
| ecological foot-<br>print | 生态足迹 | _____                      |
| Sustainability            | 可持续性 | _____                      |

### Recall

In Part A you saw how using land can harm the environment. Now measure that impact and reduce it:

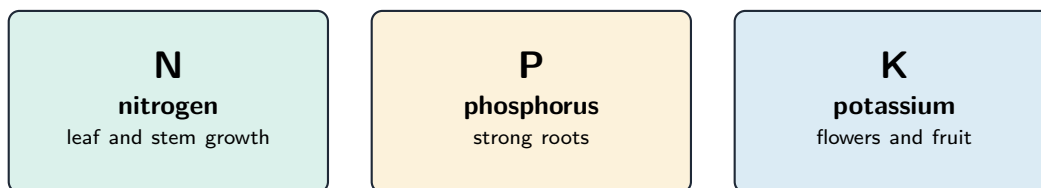
- Cities, mines, and fishing fleets all leave a mark on nature.
- We talk about living “sustainably” – using resources without using them up.

Each idea has a short worked example before the Practice.

### New ideas

#### ■ 1 Impacts of using resources

- **Overfishing** 过度捕捞 removes fish faster than they can breed, collapsing stocks.
- **Mining** scars the land and can pollute water.
- **Urbanization** 城市化 covers land with roads and buildings, increasing runoff and pollution.



**NPK** fertilisers contain all three - ammonium salts and nitrates supply the nitrogen

## ■ 2 Ecological footprint

An **ecological footprint** 生态足迹 measures the land and water one person needs to supply their resources and absorb their wastes. Wealthy, high-consumption lifestyles have much larger footprints.

*Worked example.* Earth provides about 1.6 global hectares per person. If someone's footprint is 8 global hectares, it would take  $\frac{8}{1.6} = 5$  Earths if everyone lived that way.

## ■ 3 Sustainability

**Sustainability** 可持续性 means meeting today's needs without harming the ability of future generations to meet theirs – using resources no faster than they renew.

## ■ 4 Sustainable methods

Better practices reduce harm: **integrated pest management** (using natural predators plus minimal pesticide), crop rotation, sustainable forestry (replanting), and fishing limits.

**Watch out:** an ecological footprint is measured **per person**, so a small rich country can have a bigger total impact than a large poor one. Consumption per person, not just population, drives the footprint.

## Practice

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Try these in order. The methods are all above.

**2.1** Explain what overfishing is and why it is a problem. [2]

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**2.2** State one environmental impact of urbanization. [1]

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**2.3** An average footprint is 2.4 global hectares and Earth provides 1.6 per person. Find how many Earths would be needed if everyone lived this way. [2]

**2.4** State what “sustainability” means. [2]

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**2.5** Give one sustainable farming or fishing practice. [1]

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

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

**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!**

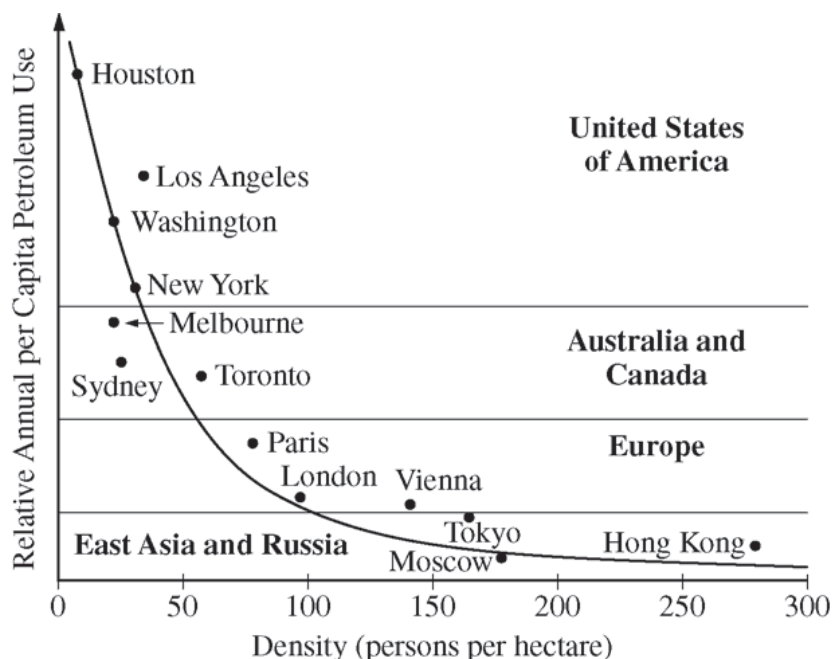
A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil 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.

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**



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- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

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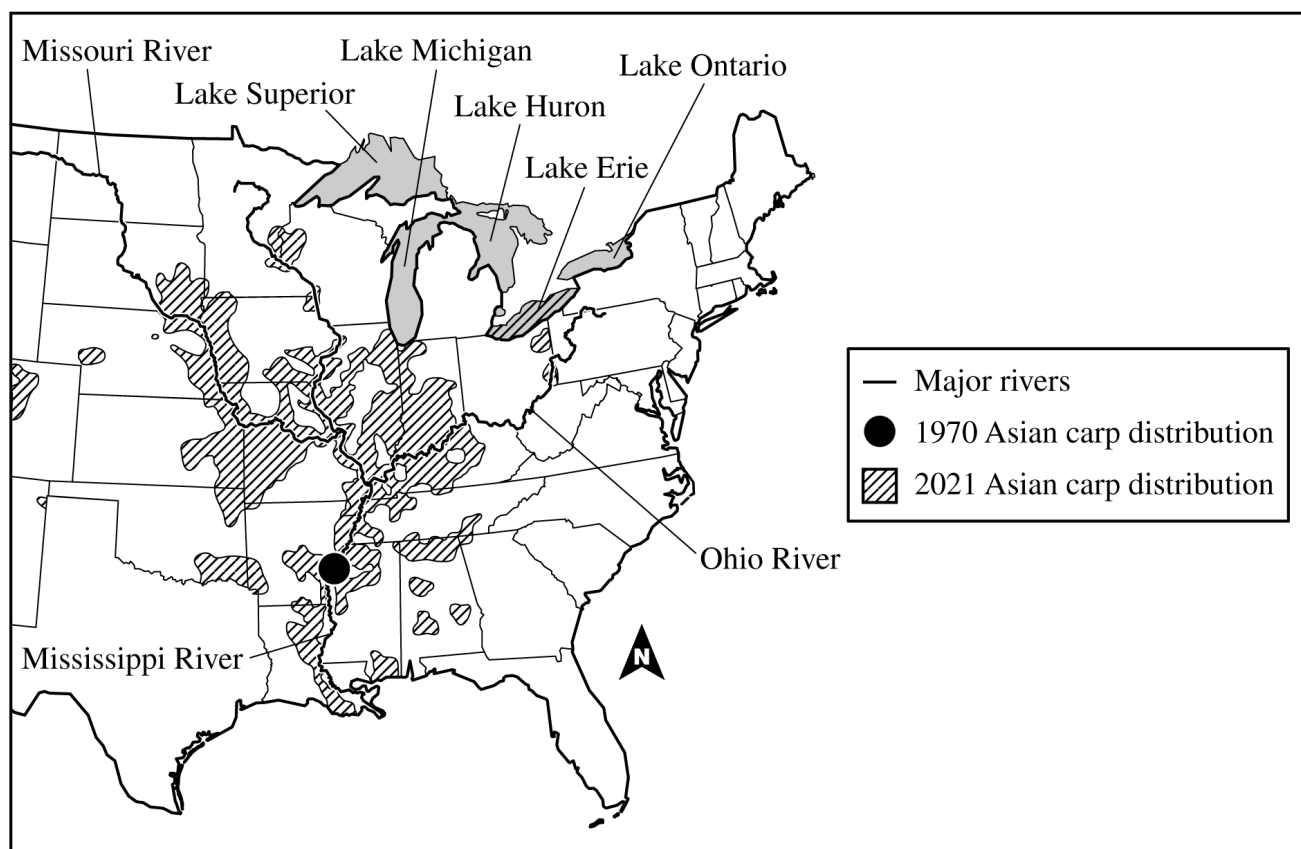
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## Distribution of the Asian Carp in the United States



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The following is an example of a simple food chain in the Great Lakes.

Algae → Zooplankton → Macroinvertebrates → Yellow perch → Rainbow trout

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The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(i) **Describe** one way that overfishing of blue pike illustrates the tragedy of the commons.

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# 6 Non-renewable energy – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English                | 中文     | Write it 3 times (English) |
|------------------------|--------|----------------------------|
| renewable resource     | 可再生资源  | _____                      |
| non-renewable resource | 不可再生资源 | _____                      |
| Fossil fuels           | 化石燃料   | _____                      |
| Nuclear power          | 核能     | _____                      |
| fission                | 裂变     | _____                      |

## Recall

You already use energy from many sources:

- Coal, oil, and natural gas are burned for electricity and transport.
- Nuclear power stations make electricity without burning fuel.
- Some energy sources will eventually run out.

This sheet lines up the non-renewable energy sources. Each idea has a short worked example.

## New ideas

### ■ 1 Renewable and non-renewable

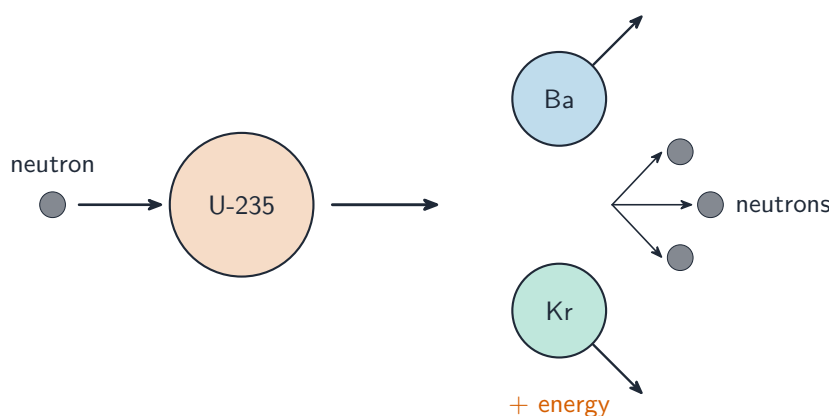
A **renewable resource** 可再生资源 replenishes on a human timescale (sun, wind, water). A **non-renewable resource** 不可再生资源 exists in fixed amounts that take millions of years to form (fossil fuels, nuclear fuel).

## ■ 2 Fossil fuels

**Fossil fuels** 化石燃料 (coal, oil, gas) are energy-dense and reliable, but they are non-renewable and release **carbon dioxide** and other pollutants when burned.

## ■ 3 Nuclear power

**Nuclear power** 核能 splits uranium (**fission** 裂变) to make heat and then electricity. It produces **no CO<sub>2</sub>**, but leaves long-lived radioactive **waste**.



## ■ 4 The half-life of waste

Radioactive waste decays by its **half-life** – the time for half of it to decay.

*Worked example.* If an isotope has a half-life of 30 years and you start with 100 g, after 30 years 50 g remains, after 60 years 25 g, and after 90 years just 12.5 g.

**Watch out:** nuclear power makes no CO<sub>2</sub>, but its waste stays dangerous for a very long time (many half-lives), so it must be stored safely for centuries.

## Practice

Try these in order. The methods are all above.

**2.1** State the difference between a renewable and a non-renewable resource. [2]

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**2.2** State one advantage and one disadvantage of fossil fuels. [2]

---

---

**2.3** State one advantage and one disadvantage of nuclear power. [2]

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**2.4** An isotope has a half-life of 10 years. Starting with 80 g, how much remains after 30 years? [3]

**2.5** Explain why nuclear waste must be stored safely for a very long time. [2]

2. Iron ores are rocks from which metallic iron can be extracted for steel production. This process involves several steps. Iron ore is first mined and then turned into pig iron in a blast furnace, and some rock waste such as silicon dioxide is separated out. In the final step, the pig iron is refined into steel using a process that includes reacting the molten pig iron with oxygen to remove impurities.

(a) Use the data below to respond to the following. For each calculation, show all your work.

| Global Iron and Steel Data                                     |
|----------------------------------------------------------------|
| 1.6 billion tons of iron ore are used yearly to make pig iron. |
| 1.2 billion tons of pig iron are produced each year.           |
| Iron ore reserves are estimated to be 800 billion tons.        |
| 95% of iron ore that is mined is used in steel production.     |

- (i) **Calculate** the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.
- (ii) **Calculate** the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.
- (iii) **Calculate** the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

Both iron ore and coal are mined for use in the manufacture of steel. It is estimated that for every ton of steel recycled, 1.25 fewer tons of iron ore and 0.7 fewer tons of coal must be mined. About 80 million tons of steel are recycled each year in North America.

- (b) **Calculate** the weight (in tons) of coal that is conserved each year in North America by recycling steel.

Before the year 1900, most mining companies abandoned surface and subsurface coal mine sites once the resource was depleted.

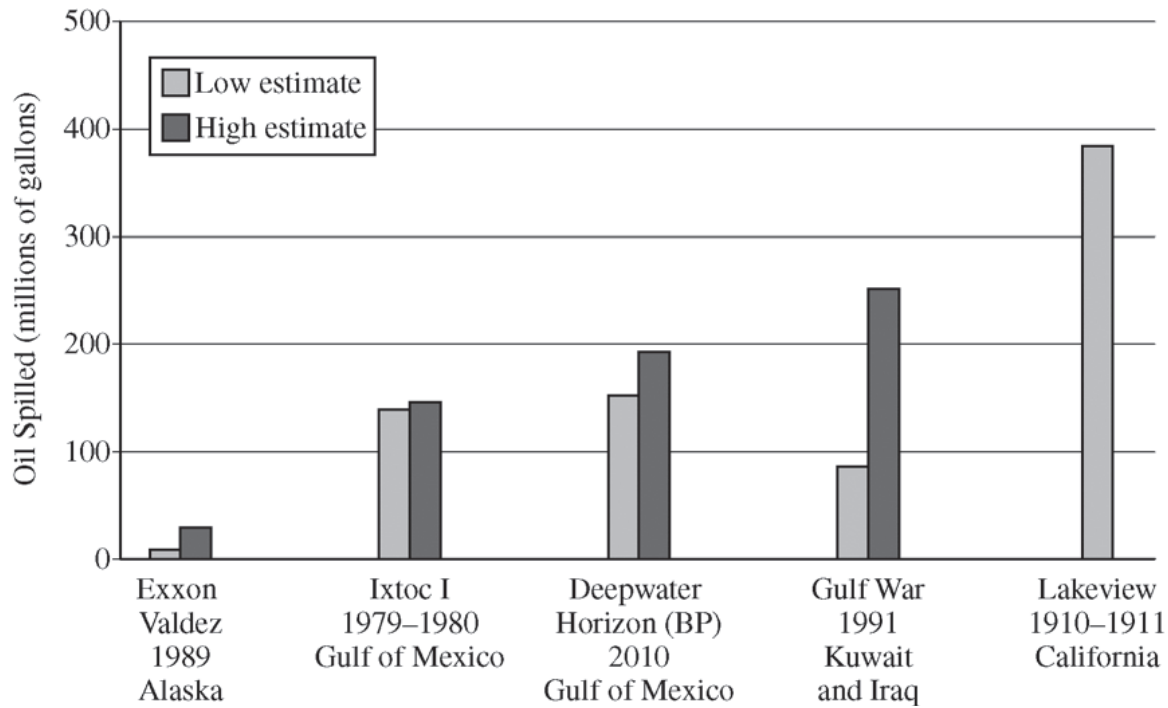
- (c) **Describe** TWO environmental problems that are associated with abandoned coal mine sites.
- (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).
- (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
- (a) **Describe** one environmental benefit associated with an offshore wind project.
  - (b) **Identify** and **describe** one potential economic effect of an offshore wind project.
  - (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be  $2.0 \times 10^6$  MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

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).

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- (d) **Describe** one method that can be used to mitigate one of the problems you identified in part (c).
- (e) **Discuss** one reason why surface coal mining is generally less expensive than subsurface mining.

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,  $4.1 \times 10^{12}$  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)  $7.4 \times 10^7$  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,  $8.99 \times 10^{11}$  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.

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**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**



## 6 Renewable energy and conservation

### – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English             | 中文    | Write it 3 times (English) |       |       |
|---------------------|-------|----------------------------|-------|-------|
| solar               | 太阳能   | _____                      | _____ | _____ |
| wind                | 风能    | _____                      | _____ | _____ |
| hydroelectric       | 水电    | _____                      | _____ | _____ |
| geothermal          | 地热能   | _____                      | _____ | _____ |
| Biomass             | 生物质   | _____                      | _____ | _____ |
| hydrogen fuel cell  | 氢燃料电池 | _____                      | _____ | _____ |
| Energy conservation | 节能    | _____                      | _____ | _____ |

### Recall

In Part A you met fossil fuels and nuclear power. Now the cleaner alternatives:

- Solar panels and wind turbines make electricity without burning anything.
- Dams use flowing water to generate power.
- Saving energy is often the cheapest option of all.

Each idea has a short worked example before the Practice.

### New ideas

## ■ 1 The main renewables

Clean, renewable sources make electricity without fuel:

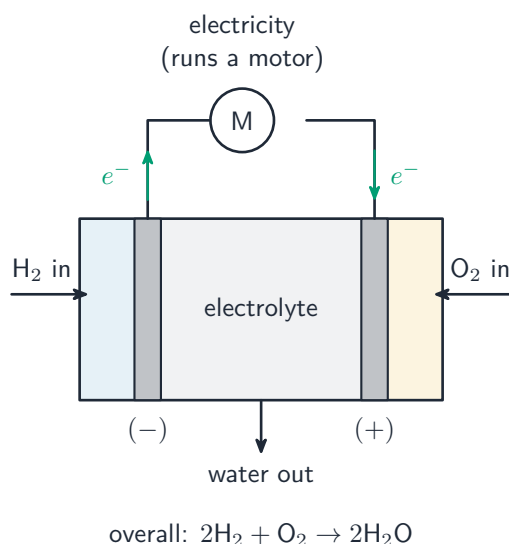
- **solar** 太阳能 – from sunlight (but only in daytime),
- **wind** 风能 – from moving air (but only when it blows),
- **hydroelectric** 水电 – from flowing water in dams,
- **geothermal** 地热能 – from Earth's internal heat.

## ■ 2 Their trade-offs

They are clean during use, but many are **intermittent** (sun and wind come and go) and need particular locations or large areas.

## ■ 3 Biomass and hydrogen

**Biomass** 生物质 (wood, crops, waste) is renewable but pollutes when burned. A **hydrogen fuel cell** 氢燃料电池 makes electricity from hydrogen and oxygen, with only water as waste.



## ■ 4 Energy conservation

**Energy conservation** 节能 – using less through efficient lights, insulation, and public transport – is often the cheapest and cleanest choice, because the energy you do not use needs no fuel.

**Watch out:** solar and wind are **intermittent** – they only produce power when the sun shines or the wind blows – so they usually need storage (batteries) or a backup supply to give steady electricity.

## Practice

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Try these in order. The methods are all above.

**2.1** Name four renewable sources of electricity. [2]

---

---

**2.2** State what “intermittent” means for solar and wind power. [2]

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**2.3** State the only waste product of a hydrogen fuel cell. [1]

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**2.4** Explain why energy conservation is often described as the cheapest and cleanest option. [2]

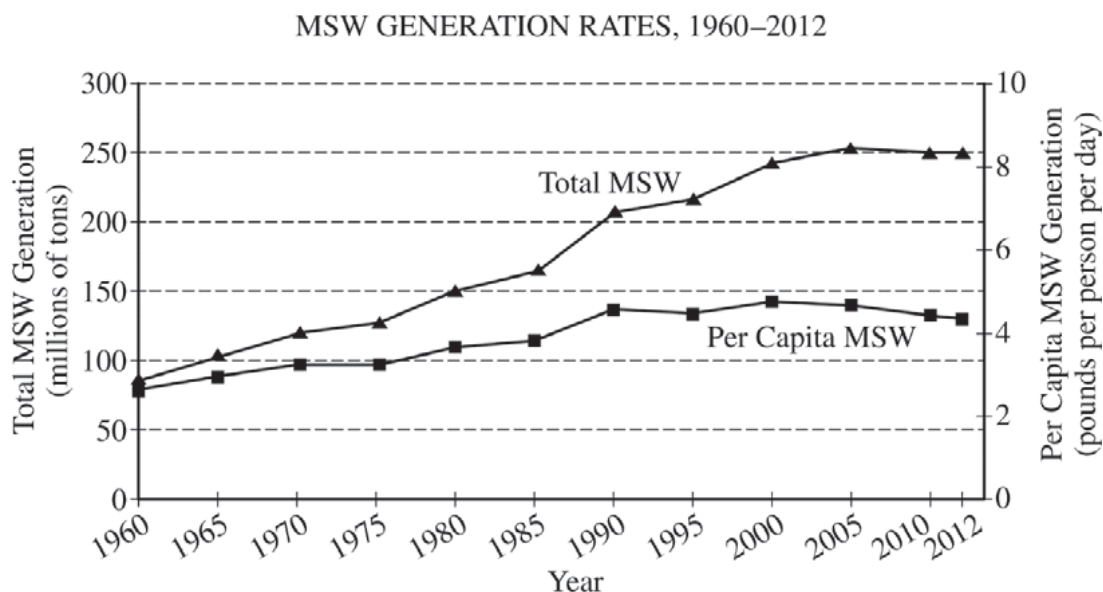
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**2.5** Give one drawback of hydroelectric dams. [1]

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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.

3. Increasing global urbanization causes associated problems such as the formation of urban heat islands.

(a) **Describe** how urbanization leads to the formation of urban heat islands.

(b) Urban heat islands have been linked to a variety of environmental problems.

(i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands.

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands.

(c) Urban areas are increasingly using solar energy to generate electricity for residences and businesses.

(i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from \$0.11 per kWh to \$0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work.

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work.

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August.

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**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**

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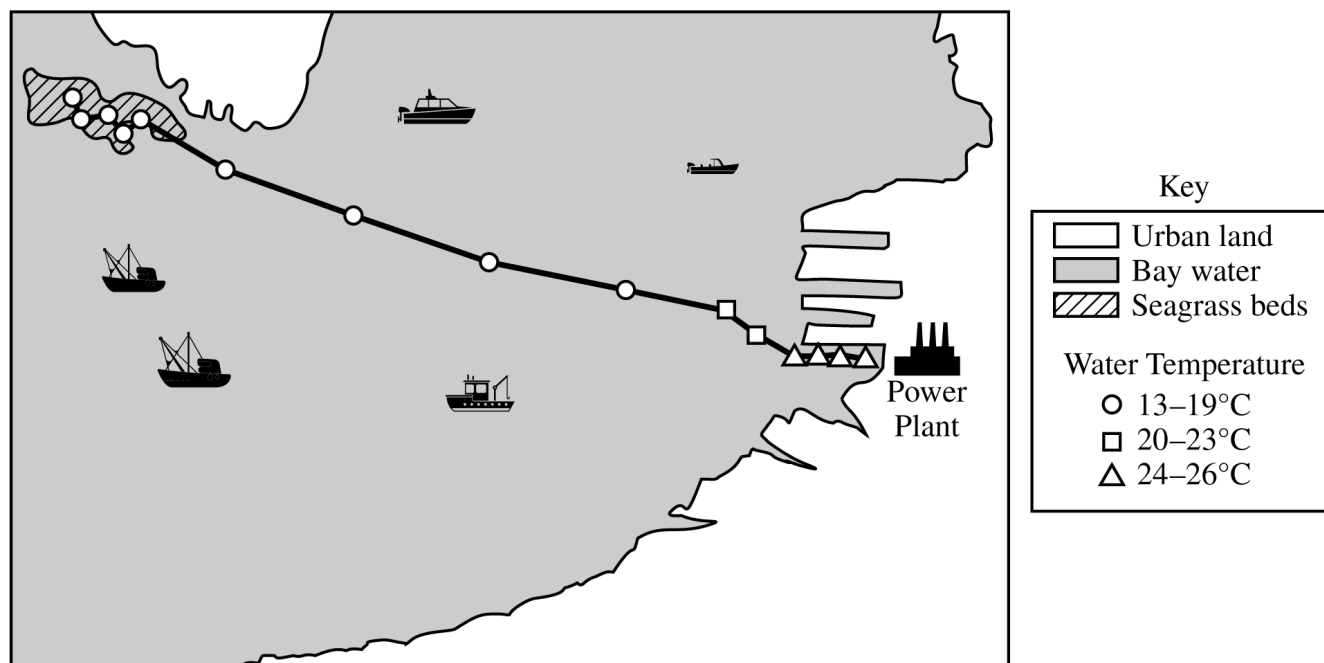
2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.
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- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.
- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.
- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

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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- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

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.

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**STOP**

**END OF EXAM**

# 7 Air pollution and smog – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English              | 中文    | Write it 3 times (English) |       |       |
|----------------------|-------|----------------------------|-------|-------|
| Air pollution        | 空气污染  | _____                      | _____ | _____ |
| Primary pollutants   | 一次污染物 | _____                      | _____ | _____ |
| secondary pollutants | 二次污染物 | _____                      | _____ | _____ |
| Photochemical smog   | 光化学烟雾 | _____                      | _____ | _____ |
| ozone                | 臭氧    | _____                      | _____ | _____ |
| thermal inversion    | 逆温    | _____                      | _____ | _____ |
| Particulate matter   | 颗粒物   | _____                      | _____ | _____ |

## Recall

You already know the air can become dirty:

- Cars, factories, and power stations release smoke and gases.
- Smog can hang over busy cities.
- Breathing polluted air is bad for your health.

This sheet lines up the main air pollutants. Each idea has a short worked example.

## New ideas

## ■ 1 Air pollution

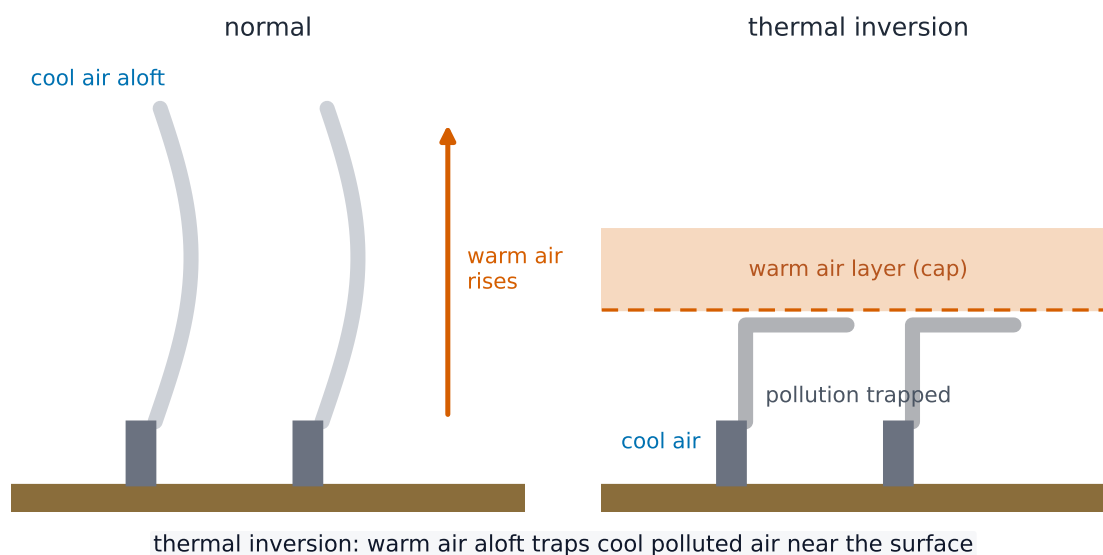
**Air pollution** 空气污染 is harmful substances in the atmosphere. **Primary pollutants** 一次污染物 are released directly (carbon monoxide, nitrogen oxides, sulfur dioxide, particulates); **secondary pollutants** 二次污染物 form later in the air from reactions.

## ■ 2 Photochemical smog

**Photochemical smog** 光化学烟雾 forms when **sunlight** drives reactions among car-exhaust gases, producing ground-level **ozone** 臭氧. It is worst in sunny, car-heavy cities and harms the lungs.

## ■ 3 Thermal inversion

Normally warm air rises and carries pollution away. In a **thermal inversion** 逆温, a layer of warm air sits **above** the cooler air, trapping pollutants near the ground and causing dangerous smog.



## ■ 4 Particulate matter

**Particulate matter** 颗粒物 is tiny solid or liquid particles that get deep into the lungs, causing breathing and heart problems and reducing visibility.

**Watch out:** ground-level ozone (in smog) is a **harmful pollutant**, but the ozone **layer** high in the atmosphere is **protective** – it shields us from the Sun's UV. Same molecule, opposite roles depending on where it is.

## Practice

---

Try these in order. The methods are all above.

**2.1** State the difference between a primary and a secondary pollutant. [2]

---

---

**2.2** State what is needed for photochemical smog to form. [2]

---

---

**2.3** Explain how a thermal inversion makes air pollution worse. [2]

---

---

**2.4** State one health effect of particulate matter. [1]

---

---

**2.5** Explain why ground-level ozone is harmful but the ozone layer is helpful. [2]

---

---

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.
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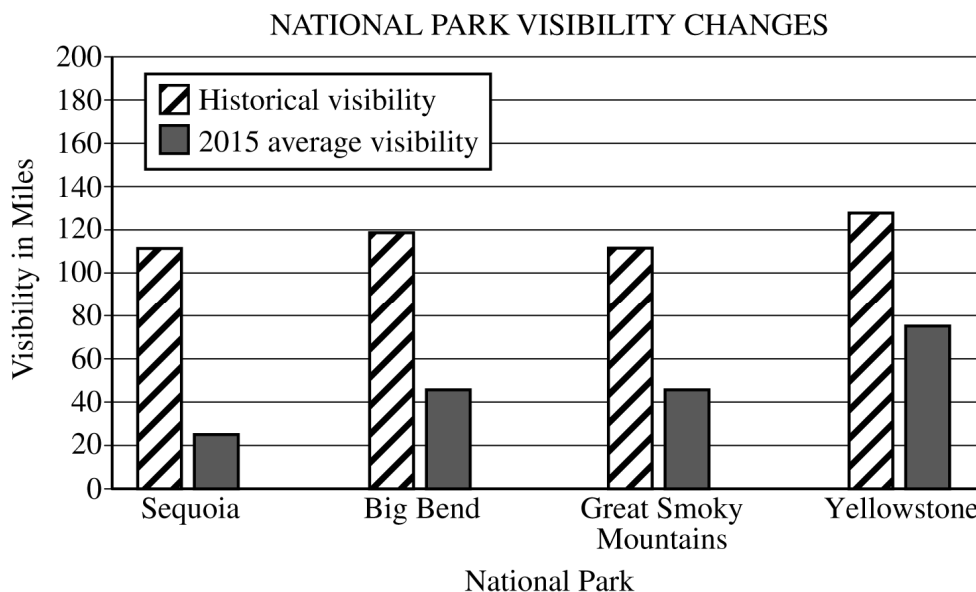
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**STOP**

**END OF EXAM**

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**

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

- A. **Identify** the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.
- B. Based on the information in Figure 1, **identify** the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.
- C. Based on the information in Figure 2, **describe** a difference in climate patterns between the regions A and B.
- D. Increases in regional precipitation can lead to increased flooding in certain locations. **Describe** one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.
- E. **Propose** a realistic solution a city could implement to decrease the risk of flooding in urban areas.
- F. **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.
- G. Terrestrial biomes are primarily determined by temperature and precipitation patterns. **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna.
- H. Droughts are one environmental problem that can affect the frequency and severity of forest fires. **Identify** the ecological process that occurs following a forest fire that leaves the soil intact.
- I. **Describe** one way burning forests contribute to atmospheric pollution.
- J. **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.



# 7 Acid rain and cleaning the air – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English              | 中文    | Write it 3 times (English) |
|----------------------|-------|----------------------------|
| Acid rain            | 酸雨    | _____                      |
| radon                | 氡     | _____                      |
| asbestos             | 石棉    | _____                      |
| catalytic converters | 催化转化器 | _____                      |
| Noise pollution      | 噪声污染  | _____                      |

## Recall

In Part A you met air pollutants. Now their effects and how we clean the air:

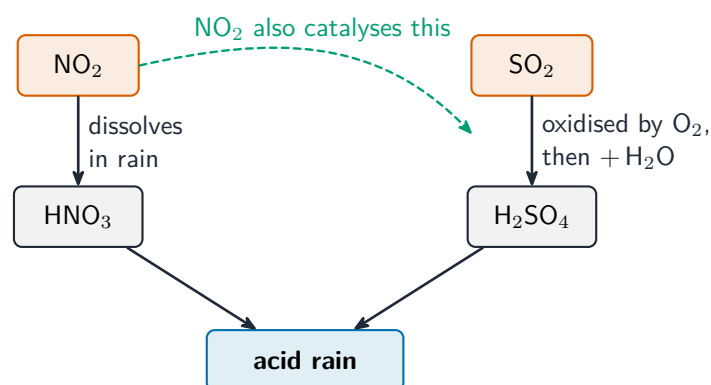
- Rain can become acidic and damage lakes and forests.
- Cars have devices that clean their exhaust.

Each idea has a short worked example before the Practice.

## New ideas

### ■ 1 Acid rain

**Acid rain** 酸雨 forms when sulfur dioxide and nitrogen oxides react with water in the air to make acids, which fall far downwind. It harms lakes and fish, damages trees, and corrodes buildings.

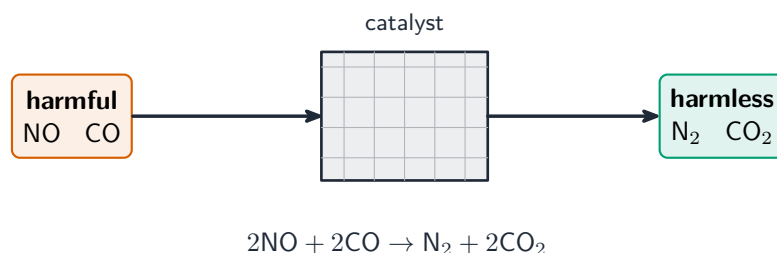


## ■ 2 Indoor air pollution

Indoor air can be worse than outdoor air. Common indoor pollutants include **radon** 氡 (a radioactive gas from the ground), carbon monoxide, and **asbestos** 石棉.

## ■ 3 Cleaning the air

Pollution is cut by technology and law: **catalytic converters** 催化转化器 on cars turn harmful gases into harmless ones, scrubbers clean smokestacks, and cleaner fuels and emission laws reduce pollution at the source.



## ■ 4 Noise pollution

**Noise pollution** 噪声污染 is unwanted or harmful sound – from traffic, aircraft, and industry. It causes hearing loss and stress in people and disturbs wildlife.

**Watch out:** acid rain often falls **far from where the pollution was released**, because the gases travel on the wind – so the country causing it may not be the one harmed.

## Practice

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Try these in order. The methods are all above.

**2.1** State the two gases that cause acid rain. [2]

---

---

**2.2** List two kinds of damage caused by acid rain. [2]

---

---

**2.3** Name one indoor air pollutant and state its danger. [2]

---

---

**2.4** State what a catalytic converter does. [2]

---

---

**2.5** Explain why acid rain can be an international problem. [2]

---

---

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. Respond to parts A, B, C, D, E, F, and G.**

- A.** One major environmental problem is air pollution. Air pollution can come from natural or anthropogenic sources. Motor vehicles can be a source of particulate matter (PM) and other pollutants.

**Identify** an anthropogenic source of particulate matter, other than from motor vehicles.

- B.** One way to reduce pollutants associated with motor vehicles is to use a vapor recovery nozzle. **Describe** one way a vapor recovery nozzle is used to reduce atmospheric pollution.
- C.** Acid rain is another air pollutant linked to motor vehicles. Over the past few years, there has been an increase in the number of people working from home, so fewer people are commuting to work in their personal vehicles.

**Explain** how a decrease in the number of people commuting to work in their personal vehicles could lead to a reduction in acid rain.

- D.** The average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city. One commuter sells their gasoline-powered SUV and replaces it with a hybrid SUV.

**Calculate** the percent change in gas mileage between the gasoline-powered SUV and the hybrid SUV based on the data provided. **Show** your work.

- E.** Both the gasoline-powered SUV and the hybrid SUV have 14-gallon gas tanks. As stated in part D, the average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city.

**Calculate** how many more miles the owner can drive in the hybrid SUV in the city than they could have driven in the gasoline-powered SUV. **Show** your work.

- F.** In addition to vehicles, buildings such as schools often have high energy consumption. The primary sources of energy use in many buildings are heating, cooling, and lighting.

**Propose** a realistic solution that schools could implement to decrease energy use for heating and cooling, other than a reduction in the amount of time the school building is occupied.

- G.** The school plans to upgrade its lighting to save money and reduce both its electricity use and its ecological footprint. The sustainability committee proposes that the school reduce its electricity use by switching to energy-efficient light-emitting diode (LED) bulbs. The school building uses  $2.8 \times 10^4$  bulbs. The LED bulbs would each use 0.0085 kilowatts per hour. Each bulb would be used for an average of 2,340 hours per year.

**Calculate** the energy use in the school building in kilowatts per year using LED light bulbs. **Show** your work.

**STOP**

**END OF EXAM**

4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.
- (a) **Describe** how TWO climate factors affect the rate of soil formation.
  - (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
    - (i) **Identify** one specific biotic component of the A horizon.
    - (ii) **Identify** one abiotic component of the A horizon.

Resources such as soil and water can be degraded by human activities.

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
  - (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
  - (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
  - (i) **Explain** one way acid deposition onto soil can affect plant health.
  - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

**STOP**

**END OF EXAM**

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

3. Respond to parts A, B, C, D, E, F, and G.

A. **Identify** a type of surface mining the company could use to access the coal.

B. **Describe** an environmental problem associated with surface mining.

C. The town is located downwind of the new coal-burning power plant.

**Describe** an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

D. The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

**Propose** a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

E. Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses  $1.064 \times 10^4$  kWh of electricity each year.

**Calculate** how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

F. Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

**Calculate** the percent change in bird species per hectare since the power plant was installed. **Show** your work.

G. The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

**STOP**

**END OF EXAM**





# 8 Water pollution and biomagnification – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English           | 中文   | Write it 3 times (English) |
|-------------------|------|----------------------------|
| eutrophication    | 富营养化 | _____                      |
| Thermal pollution | 热污染  | _____                      |
| Bioaccumulation   | 生物累积 | _____                      |
| Biomagnification  | 生物放大 | _____                      |

## Recall

You already know water can be polluted:

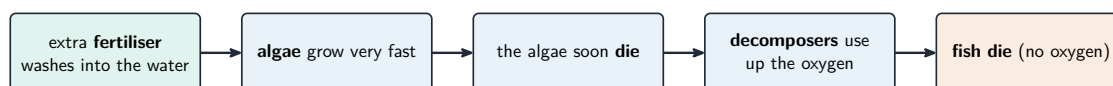
- Sewage, fertilizer, and factory waste can enter rivers and seas.
- Too much fertilizer can cause a green bloom of algae in a pond.
- Some poisons build up in animals over time.

This sheet lines up water pollution. Each idea has a short worked example.

## New ideas

### ■ 1 Eutrophication

When extra nutrients (from fertilizer or sewage) enter water, they cause **eutrophication** 富营养化: algae bloom, then die and rot, using up the oxygen, which suffocates fish.



## ■ 2 Thermal pollution

**Thermal pollution** 热污染 is warm water released by power plants; warm water holds less oxygen, stressing aquatic life.

## ■ 3 Bioaccumulation and biomagnification

**Bioaccumulation** 生物累积 is the build-up of a toxin **inside one organism** over its life. **Biomagnification** 生物放大 is the increase in concentration **up the food chain**, so top predators end up with the most.

## ■ 4 Biomagnification in numbers

*Worked example.* If water holds a toxin at 0.01 ppm, plankton might reach 0.5 ppm, small fish 2 ppm, and a top predator 25 ppm – about 2500 times the level in the water.

**Watch out:** because toxins **biomagnify**, a top predator (like an eagle or a large fish) can be poisoned even when the water itself is only lightly polluted.

## Practice

---

Try these in order. The methods are all above.

**2.1** Explain the steps of eutrophication, from fertilizer runoff to dead fish. [3]

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**2.2** State why warm water from power plants harms aquatic life. [2]

---

---

**2.3** State the difference between bioaccumulation and biomagnification. [2]

---

---

**2.4** A toxin is 0.02 ppm in water and 40 ppm in a top predator. Find how many times

more concentrated it is in the predator.

[2]

**2.5** Explain why top predators are most affected by biomagnification.

[2]

## ENVIRONMENTAL SCIENCE

## SECTION II

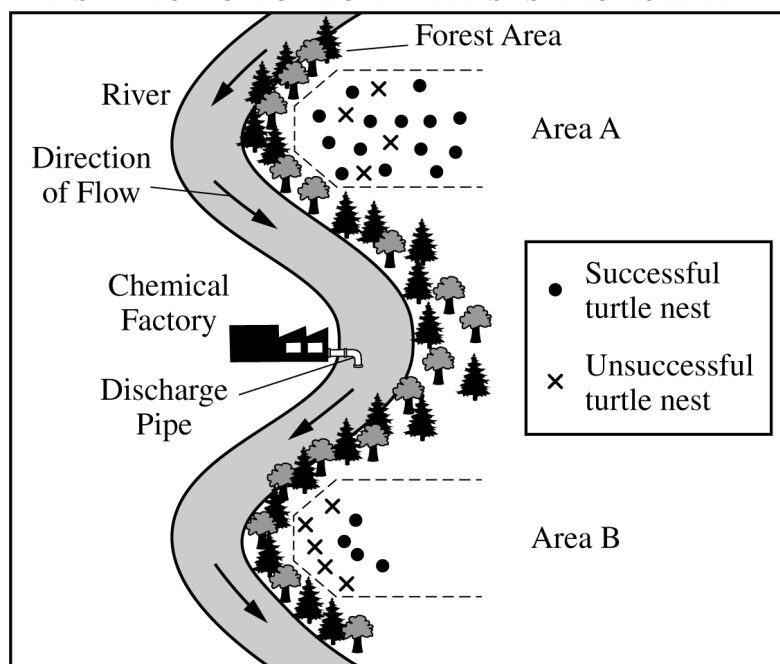
Time—1 hour and 10 minutes

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

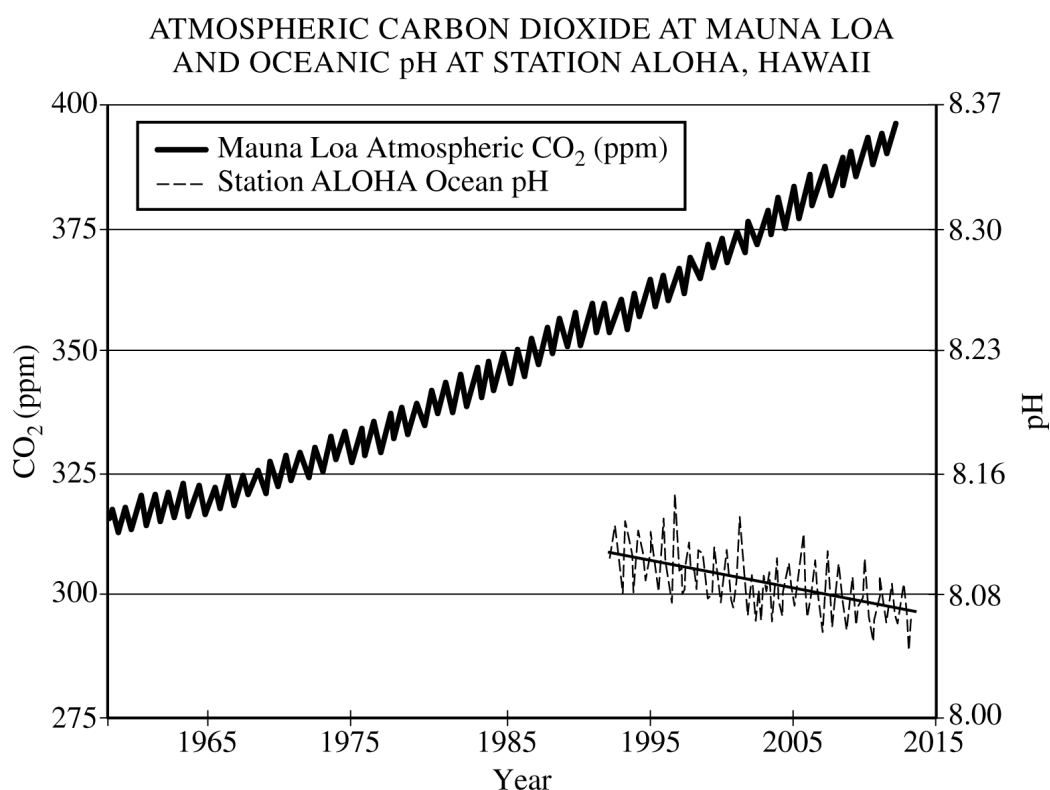


- (a) The map shows locations of both successful and unsuccessful turtle nests.
- (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram.
  - (ii) **Identify** the dependent variable in the study.
  - (iii) Based on the information provided, **identify** 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.

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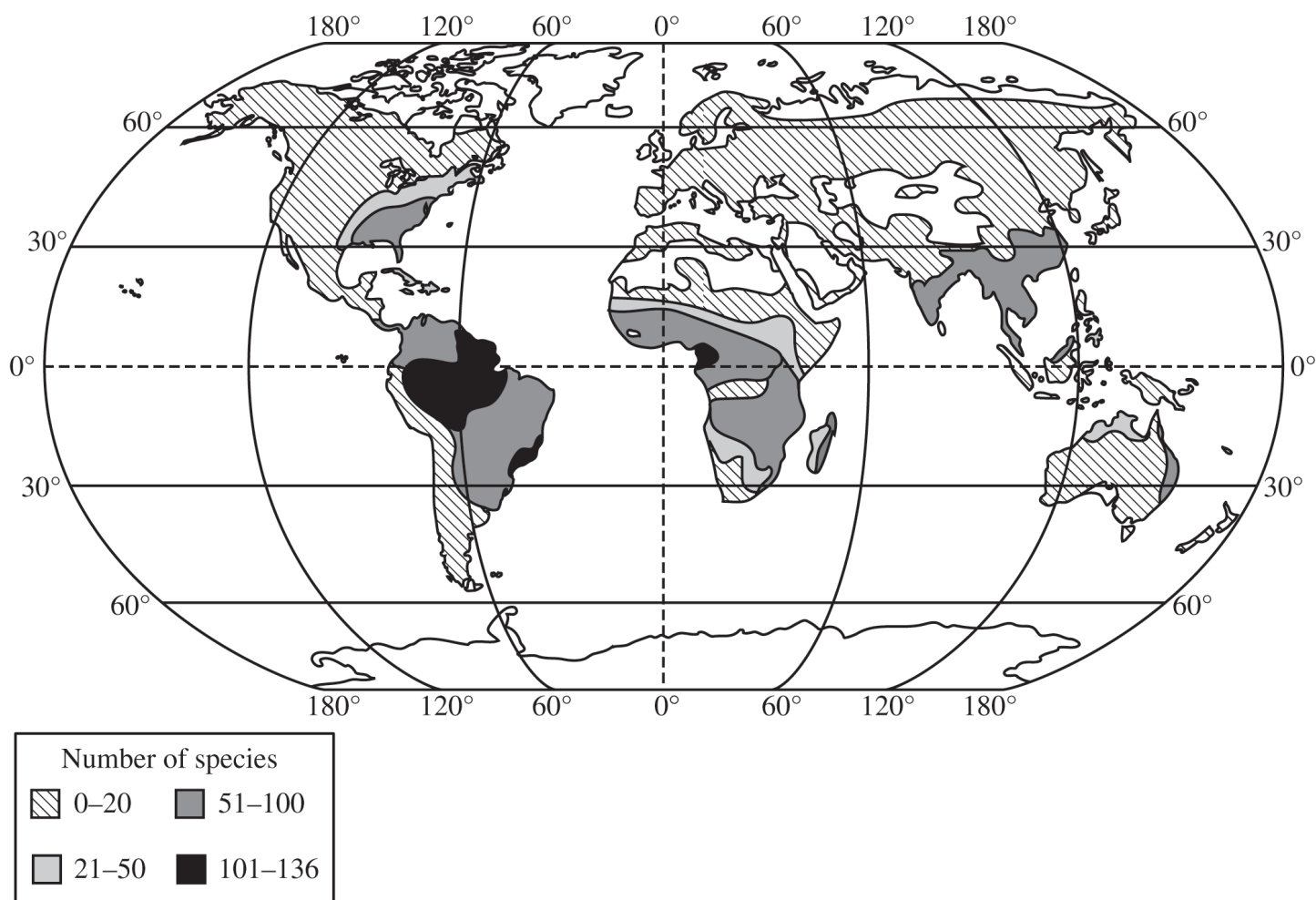
**Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.**

3. The graph shows measurements of atmospheric levels of carbon dioxide ( $\text{CO}_2$ ) 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  $\text{CO}_2$  (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  $\text{CO}_2$  on the concentration of  $\text{CO}_2$  in the ocean.
  - Based on the data, **identify** the relationship between the concentration of atmospheric  $\text{CO}_2$  and the pH of ocean water.
  - Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide ( $\text{CO}_2$ ) and water ( $\text{H}_2\text{O}$ ).
  - 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.

## 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.

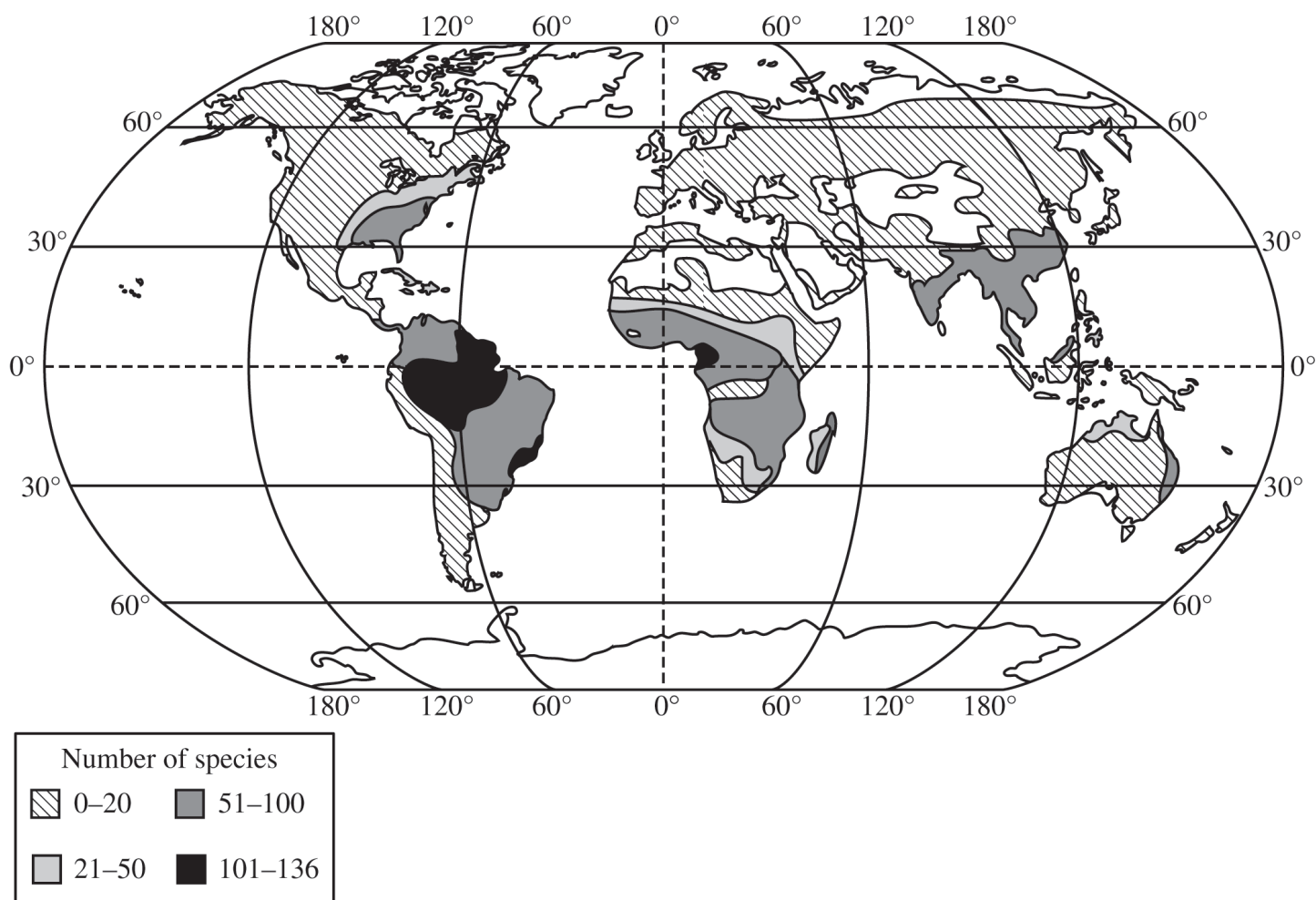
- (i) **Identify** one specific piece of legislation that has been designed to protect species threatened by extinction.
- (ii) **Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction.
- (e) A town is considering selling an undeveloped 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.**



## GLOBAL AMPHIBIAN SPECIES RICHNESS



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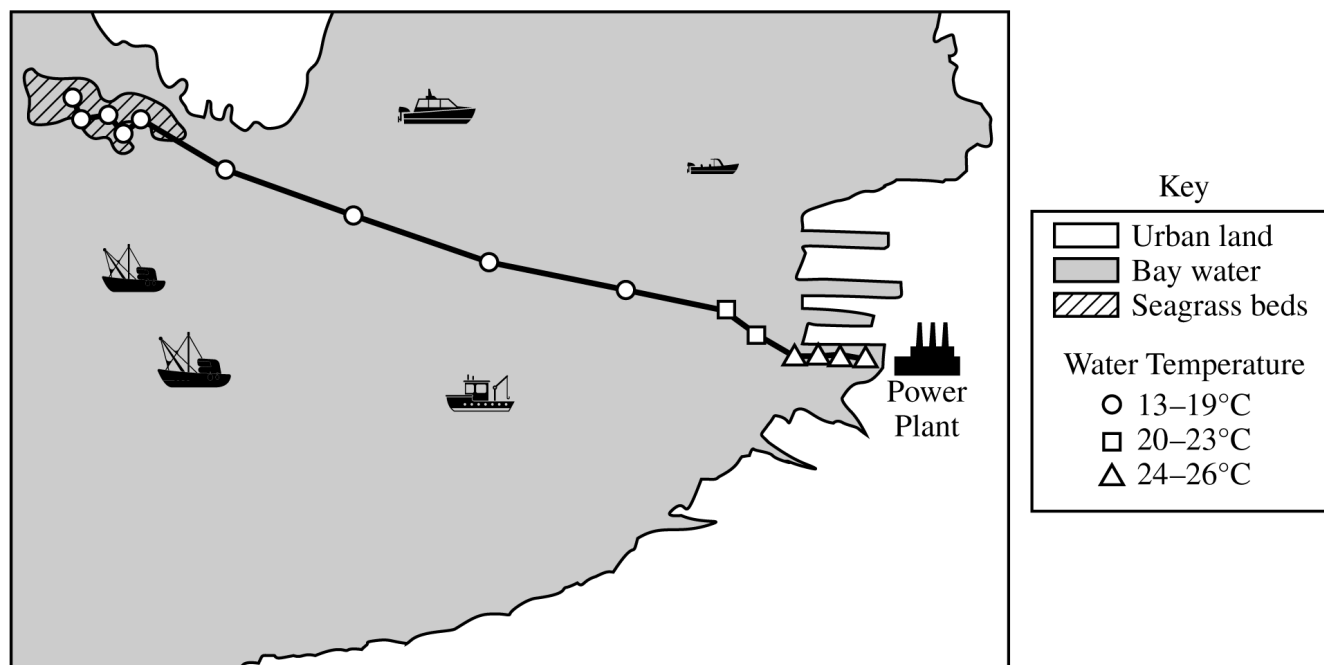
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---

**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. 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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**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. 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,  $4.1 \times 10^{12}$  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)  $7.4 \times 10^7$  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,  $8.99 \times 10^{11}$  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.

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**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**

# 8 Waste, sewage, and health – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English            | 中文    | Write it 3 times (English) |
|--------------------|-------|----------------------------|
| sanitary landfills | 卫生填埋场 | _____                      |
| Sewage treatment   | 污水处理  | _____                      |
| LD50               | 半数致死量 | _____                      |
| Pathogens          | 病原体   | _____                      |

## Recall

In Part A you met water pollution. Now waste, sewage, and toxic chemicals:

- We throw away huge amounts of rubbish.
- Sewage must be cleaned before it returns to rivers.
- Some substances are far more poisonous than others.

Each idea has a short worked example before the Practice.

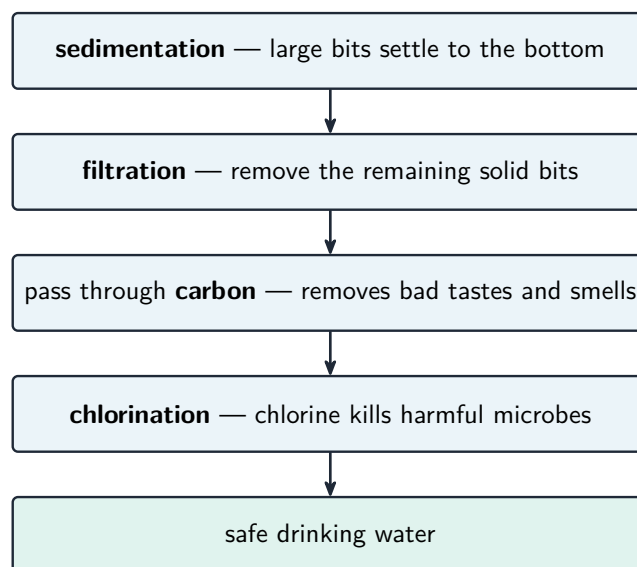
## New ideas

### ■ 1 Solid waste

Rubbish is buried in **sanitary landfills** 卫生填埋场 or burned in incinerators. Both have costs, so the best approach is **reduce, reuse, recycle** – reducing waste is best of all.

### ■ 2 Sewage treatment

**Sewage treatment** 污水处理 cleans wastewater in stages: settling out solids, then bacteria breaking down organic matter, and sometimes removing nutrients and disinfecting. This protects rivers from disease and nutrient pollution.



### ■ 3 How toxic is it? (LD50)

The **LD50** 半数致死量 is the dose that kills **half** of a test population. A **lower** LD50 means a **more toxic** substance – less is needed to be deadly.

*Worked example.* Chemical A has an LD50 of 5 mg/kg and chemical B has 500 mg/kg. A is 100 times more toxic, because far less of it is lethal.

### ■ 4 Pathogens

**Pathogens** 病原体 (disease-causing microbes) spread through contaminated water and food, causing diseases like cholera. Clean water and good sanitation are the main defences.

**Watch out:** a **lower** LD50 means **more** toxic (a small dose is deadly). Don't read a bigger number as "more dangerous" – it is the other way round.



## Practice

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Try these in order. The methods are all above.

**2.1** State the “reduce, reuse, recycle” order and which is best. [2]

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**2.2** Describe, in order, the main stages of sewage treatment. [2]

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**2.3** State what the LD50 of a substance measures. [2]

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**2.4** Chemical X has an LD50 of 10 mg/kg and chemical Y has 200 mg/kg. State which is more toxic and by how many times. [2]

**2.5** State how pathogens most commonly spread, and one way to prevent it. [2]

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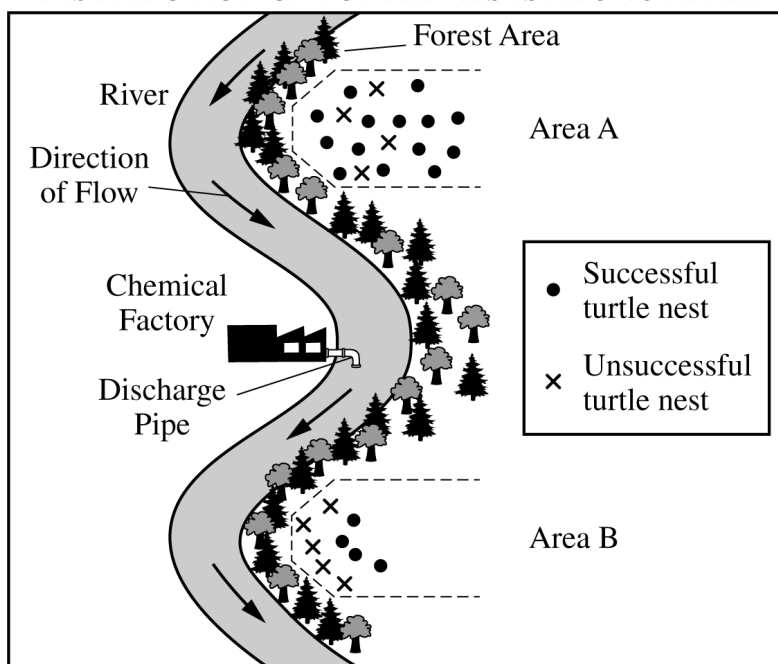
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**ENVIRONMENTAL SCIENCE****SECTION II****Time—1 hour and 10 minutes****3 Questions**

**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.

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**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                                |

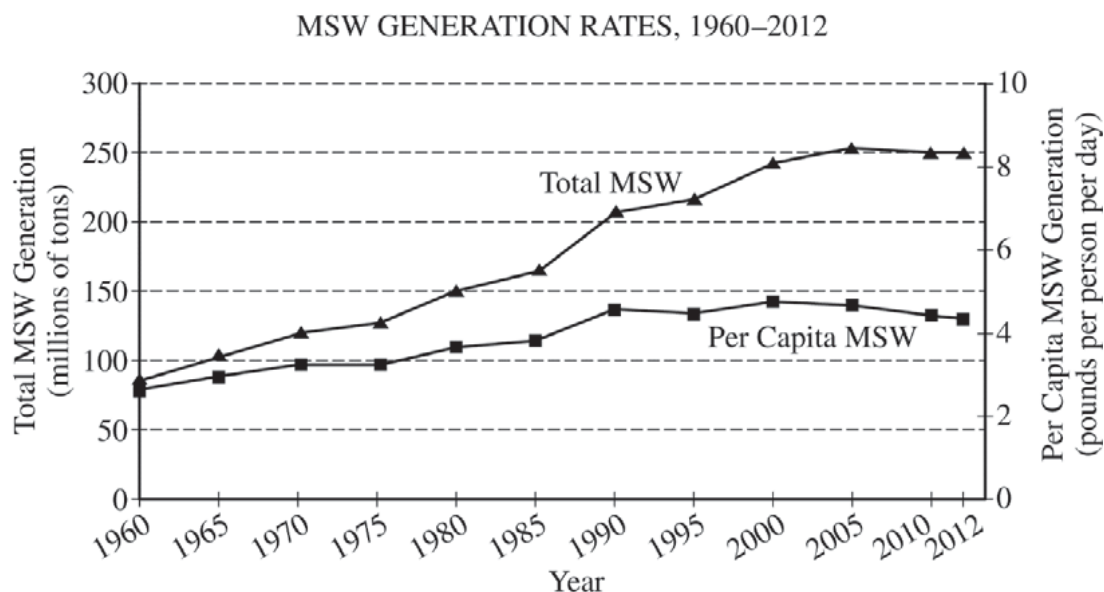
- (c) Use the data in the table to answer the following questions.
- (i) **Identify** the year when the pesticide was most effective at reducing the size of the pest population.
- (ii) **Describe** the change in the number of crop insect pests in the cotton fields over time.
- (iii) **Explain** how the 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.

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**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. 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.

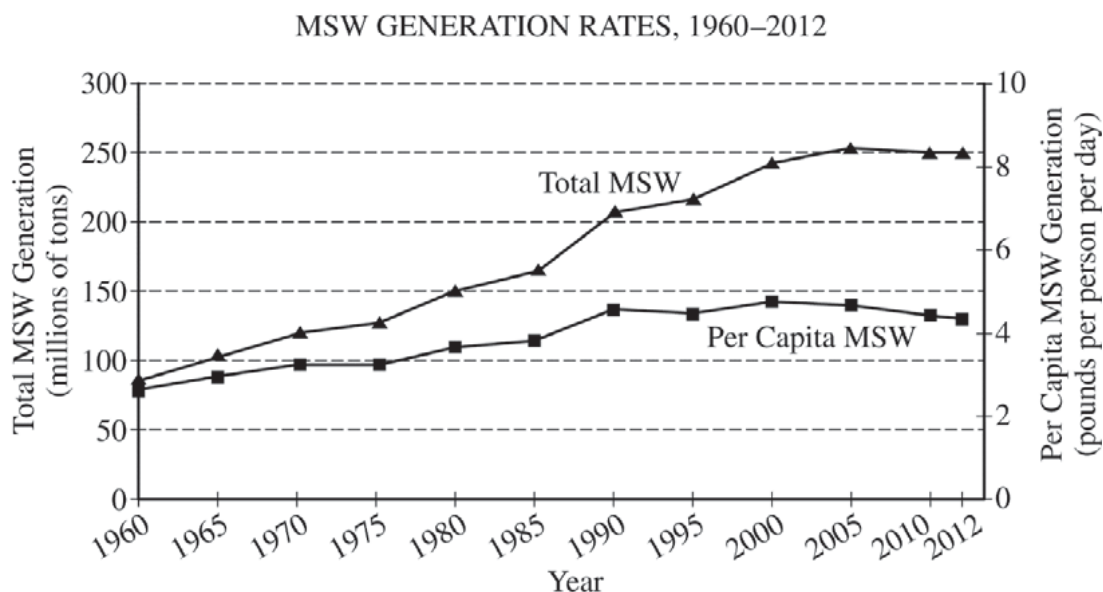


- (a) Use the data provided in the graph above to respond to the following.
- Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.
  - Calculate** the percent increase in total MSW generation from 1980 to 2012.
- (b) Two ways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

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## ENVIRONMENTAL SCIENCE

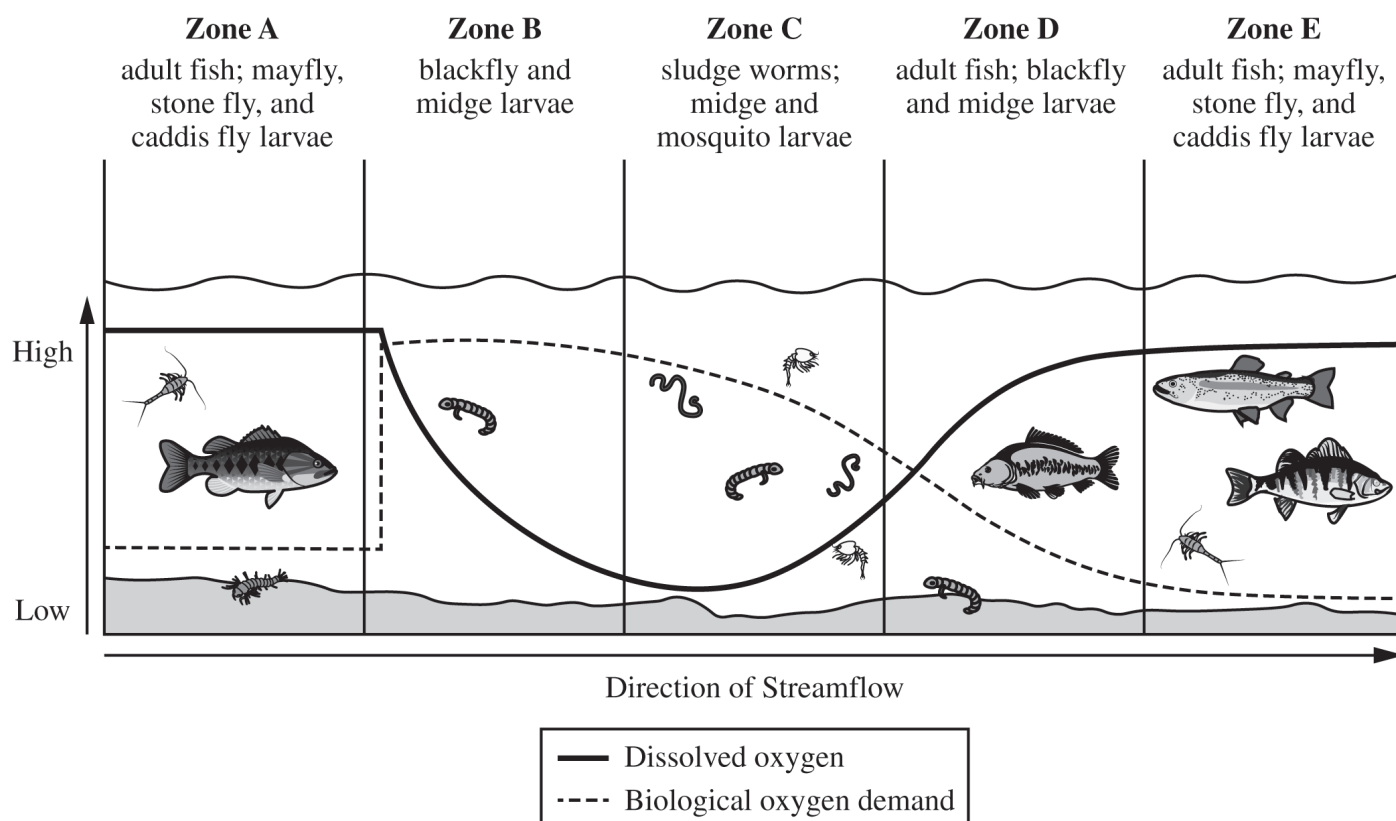
## SECTION II

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.

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**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. 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.

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**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—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.

# 9 Ozone depletion and climate change

## – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

### Vocabulary 词汇

*Write each word three times.* 把每个单词抄写三遍。

| English           | 中文          | Write it 3 times (English) |       |       |
|-------------------|-------------|----------------------------|-------|-------|
| ozone layer       | 臭氧层         | _____                      | _____ | _____ |
| ultraviolet       | 紫外线         | _____                      | _____ | _____ |
| CFCs              | 氯氟烃         | _____                      | _____ | _____ |
| Montreal Protocol | 蒙特利尔<br>议定书 | _____                      | _____ | _____ |
| greenhouse effect | 温室效应        | _____                      | _____ | _____ |
| greenhouse gases  | 温室气体        | _____                      | _____ | _____ |
| methane           | 甲烷          | _____                      | _____ | _____ |
| climate change    | 气候变化        | _____                      | _____ | _____ |

### Recall

You have probably heard about these global problems:

- The “ozone hole” high in the atmosphere.
- Global warming and the greenhouse effect.
- Carbon dioxide building up from burning fuels.

This sheet lines up ozone depletion and climate change – two different problems. Each idea has a short worked example.

## New ideas

### ■ 1 Ozone depletion

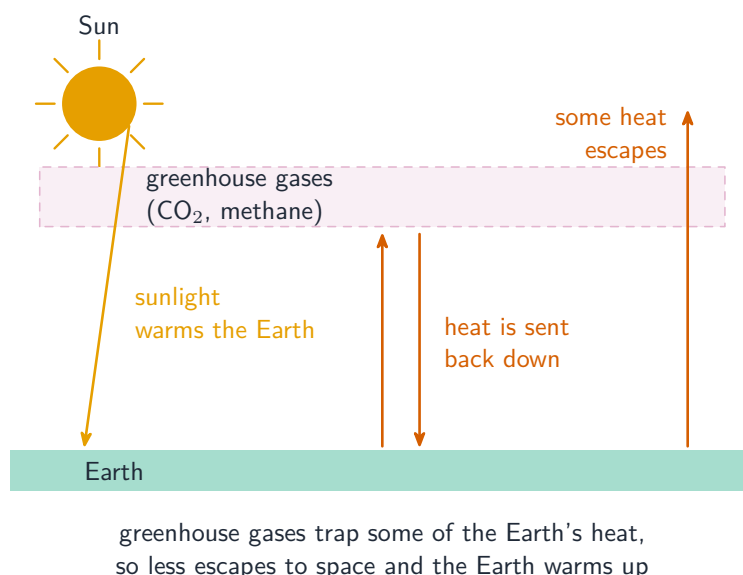
The **ozone layer** 臭氧层 high up absorbs harmful **ultraviolet** 紫外线 rays. **CFCs** 氯氟烃 (once used in fridges and sprays) destroy ozone, thinning it (the ozone hole) and letting more UV reach the surface.

### ■ 2 A rare success

The **Montreal Protocol** 蒙特利尔议定书 (1987) banned CFCs worldwide, and the ozone layer is slowly recovering – a rare environmental success story.

### ■ 3 The greenhouse effect

The **greenhouse effect** 温室效应 keeps Earth warm: **greenhouse gases** 温室气体 let sunlight in but trap the heat the Earth gives off. This is natural and makes Earth livable.



### ■ 4 Climate change

Humans add extra greenhouse gases – CO<sub>2</sub> from burning fuels and **methane** 甲烷 from livestock – strengthening the effect. This causes **climate change** 气候变化: warming, melting ice, rising seas, and more extreme weather.

**Watch out:** ozone depletion and climate change are **two different problems**. Ozone depletion is CFCs letting in more UV; climate change is greenhouse gases trapping more heat. Don't mix them up.

## Practice

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Try these in order. The methods are all above.

**2.1** State what the ozone layer does and what damages it. [2]

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---

**2.2** State why the Montreal Protocol is considered a success. [2]

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---

**2.3** Explain the natural greenhouse effect. [2]

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---

**2.4** Name two greenhouse gases and a human source of each. [2]

---

---

**2.5** State one difference between ozone depletion and climate change. [2]

---

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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**



4. Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

- (a) **Describe** how TWO climate factors affect the rate of soil formation.
- (b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
  - (i) **Identify** one specific biotic component of the A horizon.
  - (ii) **Identify** one abiotic component of the A horizon.

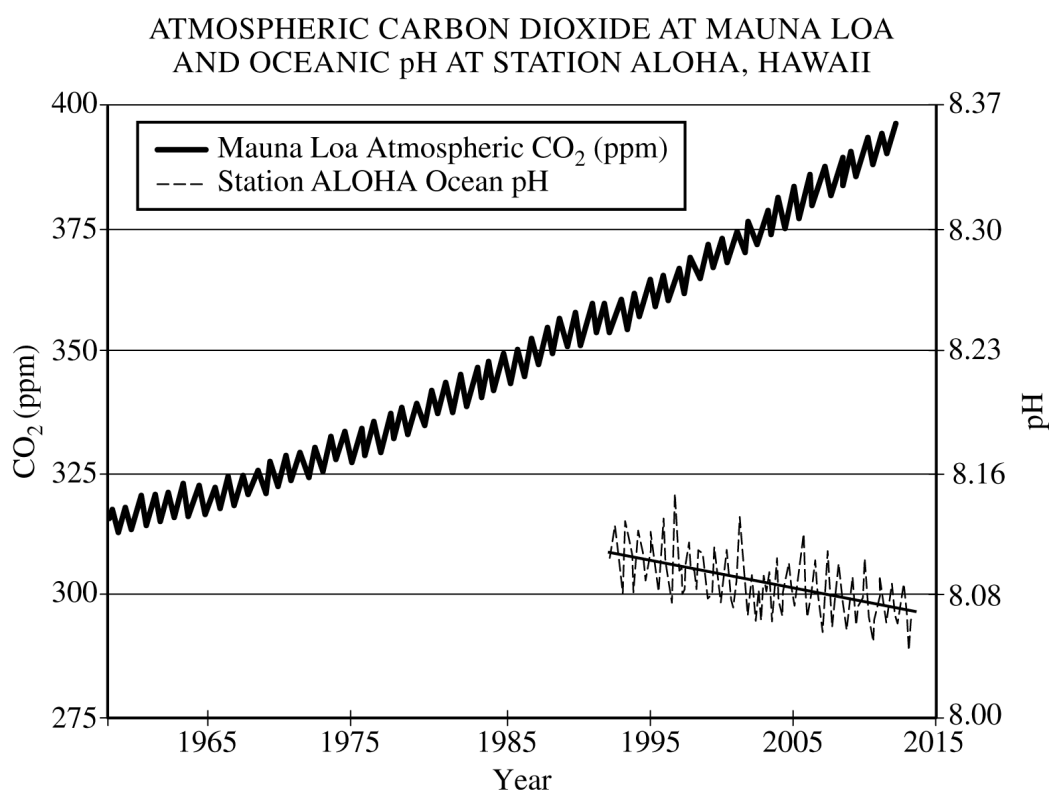
Resources such as soil and water can be degraded by human activities.

- (c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.
  - (i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.
  - (ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.
- (d) Acid deposition has affected soil quality in many parts of the northeastern United States.
  - (i) **Explain** one way acid deposition onto soil can affect plant health.
  - (ii) **Describe** one method for remediating soil affected by acid deposition.
- (e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

**STOP**

**END OF EXAM**

3. The graph shows measurements of atmospheric levels of carbon dioxide ( $\text{CO}_2$ ) 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  $\text{CO}_2$  (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  $\text{CO}_2$  on the concentration of  $\text{CO}_2$  in the ocean.
  - Based on the data, **identify** the relationship between the concentration of atmospheric  $\text{CO}_2$  and the pH of ocean water.
  - Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide ( $\text{CO}_2$ ) and water ( $\text{H}_2\text{O}$ ).
  - 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.

# 9 Oceans and biodiversity loss – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English             | 中文   | Write it 3 times (English) |
|---------------------|------|----------------------------|
| coral bleaching     | 珊瑚白化 | _____                      |
| ocean acidification | 海洋酸化 | _____                      |
| calcium carbonate   | 碳酸钙  | _____                      |
| invasive species    | 入侵物种 | _____                      |
| endangered species  | 濒危物种 | _____                      |

## Recall

In Part A you met climate change. Now its effects on the oceans and on living things:

- Warmer seas harm coral reefs.
- Some species are being pushed toward extinction.
- Animals moved to new places can cause damage.

Each idea has a short worked example before the Practice.

## New ideas

### ■ 1 Ocean warming

The oceans absorb most of the extra heat. Warmer water causes **coral bleaching** 珊瑚白化 (corals lose their algae and can die), and – with melting ice – raises sea level.

## ■ 2 Ocean acidification

The ocean absorbs some of our CO<sub>2</sub>, which forms acid – **ocean acidification** 海洋酸化. Lower pH makes it harder for corals and shellfish to build their **calcium carbonate** 碳酸钙 shells.

## ■ 3 Invasive species

An **invasive species** 入侵物种 is a non-native species that spreads and harms its new home. With no natural predators, it outcompetes native species and reduces biodiversity.

## ■ 4 Endangered species

An **endangered species** 濒危物种 is at risk of extinction. The main causes are remembered as **HIPPO**: Habitat loss, Invasive species, Pollution, Population growth, and Overharvesting.

two ways to conserve a species

**in-situ** (in the wild)  
national parks,  
marine reserves

**ex-situ** (away from the wild)  
zoos, botanic gardens,  
seed banks, frozen zoos

**Watch out:** an invasive species is dangerous precisely **because it is not native** – it has no natural predators or diseases in the new place to keep its numbers in check, so it can spread unchecked.

## Practice

Try these in order. The methods are all above.

**2.1** State what causes coral bleaching. [1]

---

**2.2** Explain how ocean acidification harms shellfish and corals. [2]

---

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**2.3** State what makes a species “invasive” and why it can spread so easily. [2]

---

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**2.4** State what the letters in HIPPO stand for. [2]

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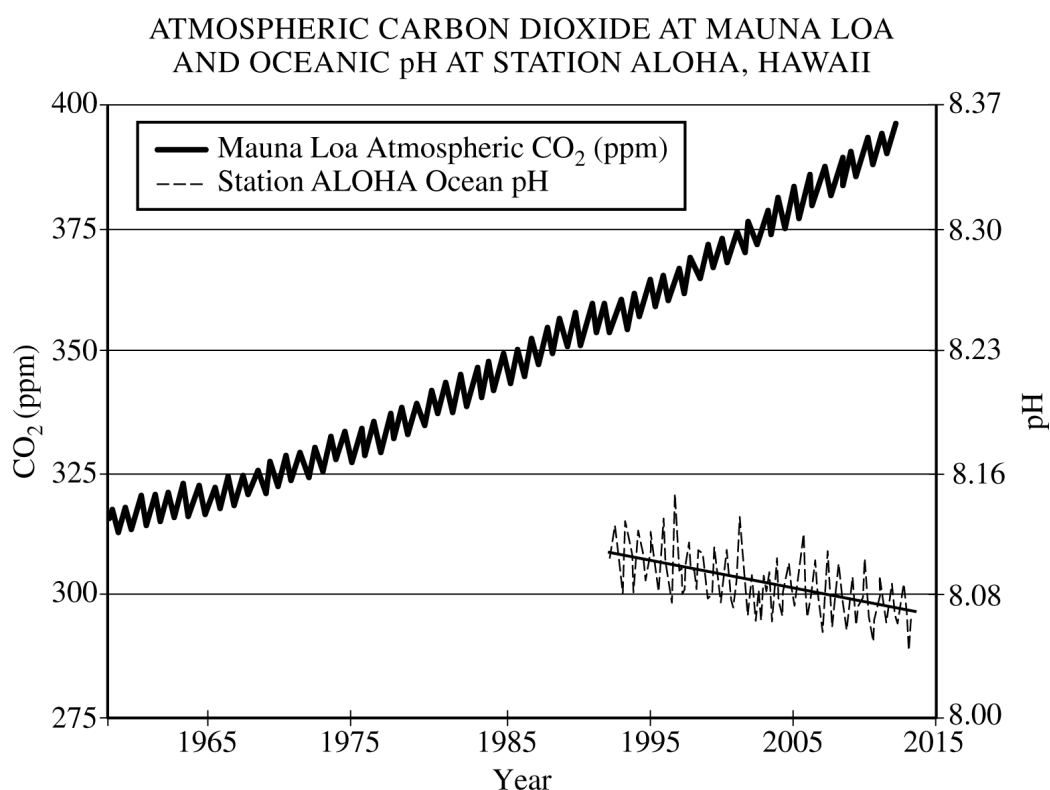
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**2.5** Give two ways people protect endangered species. [2]

---

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3. The graph shows measurements of atmospheric levels of carbon dioxide ( $\text{CO}_2$ ) 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.
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  - 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.

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

- A.** Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.
- B.** Based on the information provided, **identify** the dominant biome within the Serengeti.
- C.** Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.
- D.** The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

**Explain** why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

- E.** The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

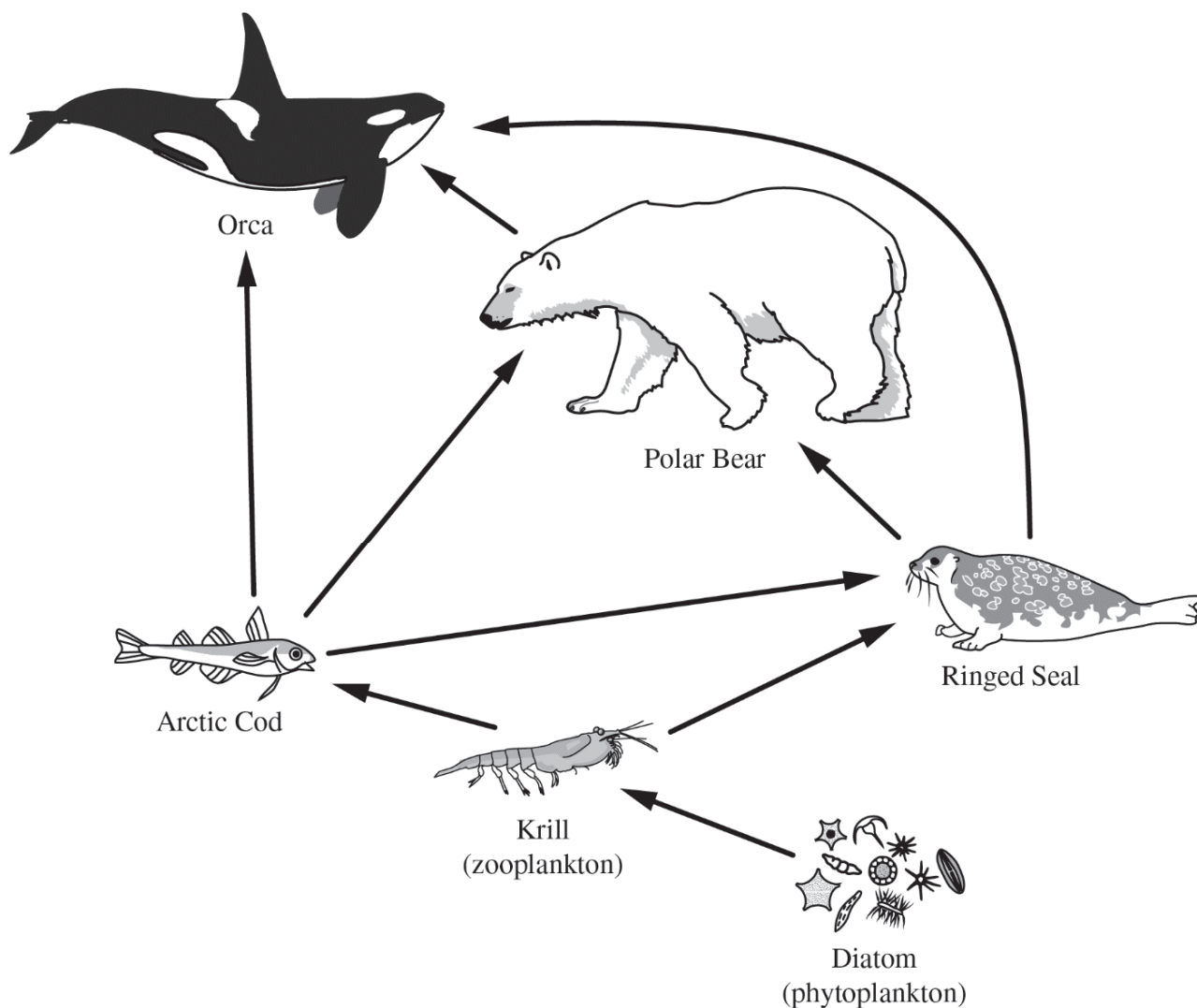
**Describe** one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

- F. Propose** a solution to the negative effect created by the planned highway described in part E.
- G.** Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

**Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

- H. Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.
- I. Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide.
- J. Propose** a solution to controlling pests, other than pesticides or crop rotation.

3. An Arctic food web includes the following organisms.



Note: Figures not drawn to scale.

(a) Refer to the food web above to complete the following table.

|                                            | Organism from Arctic food web |
|--------------------------------------------|-------------------------------|
| (i) <b>Identify</b> a primary producer     |                               |
| (ii) <b>Identify</b> a primary consumer    |                               |
| (iii) <b>Identify</b> a secondary consumer |                               |

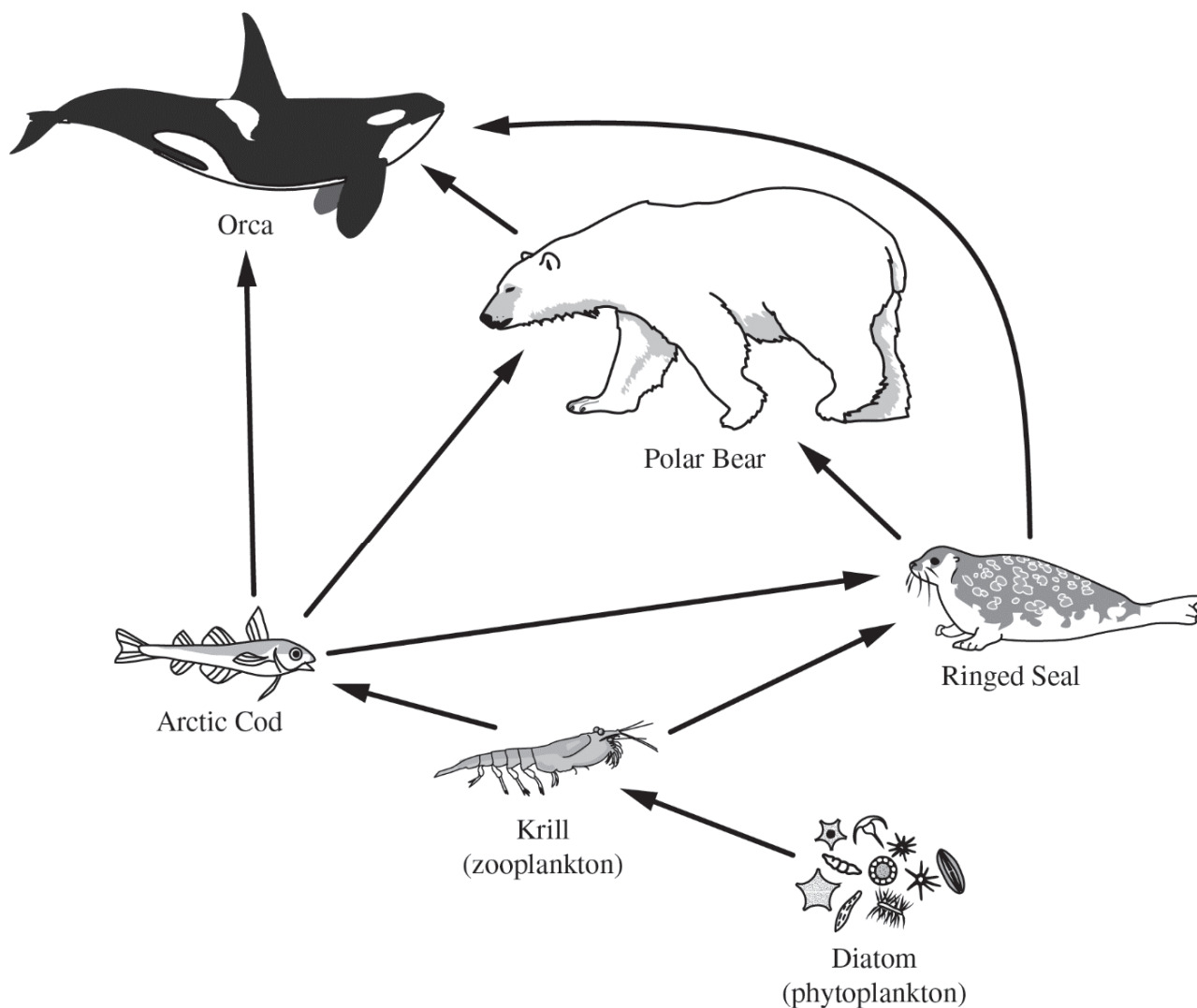
(b) Other than showing which organisms are consumed by other organisms, **describe** what is indicated by the direction of the arrows in the diagram.



As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.
- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.
- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.
  - (i) **Provide** one reason a species may migrate a long distance.
  - (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.
  - (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

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