

# Unit 4 Final Exam Review Package: Atmosphere, Climate, and Human Stewardship

## Introduction

Welcome to your final review for Unit 4: Atmosphere, Climate, and Human Stewardship. This package has been carefully designed to help you consolidate your knowledge and prepare for your Environmental Science 20 final exam. Think of this review not as a test, but as a tool to build your confidence. By working through the key terms, core concepts, and practice questions, you will reinforce what you've learned and pinpoint the most critical information needed for success. Let's get started!

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## 1.0 Key Terms Glossary

### 1.1 Introduction to Core Vocabulary

Mastering the vocabulary of this unit is the first and most crucial step toward success on your exam. A precise understanding of these terms is the foundation upon which all other knowledge is built. Knowing these definitions will allow you to deconstruct complex questions, understand environmental processes, and articulate your answers with clarity and accuracy.

### 1.2 Glossary Table

Term	Definition
<b>Air Quality Health Index (AQHI)</b>	A scale that measures the health risk associated with local air pollution levels.
<b>Albedo</b>	The reflectivity of a surface. Ice has high albedo (reflects heat); dark water has low albedo (absorbs heat).
<b>Anthropogenic Greenhouse Effect</b>	The enhancement of the natural greenhouse effect caused by human activity, metaphorically adding “extra blankets” to the atmosphere.
<b>Biological Nutrient Removal (BNR)</b>	A process that uses specific bacteria to remove nitrogen and phosphorus from wastewater to prevent eutrophication.
<b>Carbon Capture and Storage (CCS)</b>	A technology that captures carbon dioxide ( $\text{CO}_2$ ) emissions, typically using an <b>amine solution</b> to bind with the gas, before compressing it and pumping it deep underground for permanent storage.
<b>Circular Economy</b>	An economic model where resources are kept in use for as long as possible, with a focus on recycling and reusing materials.
<b>Dendrochronology</b>	The scientific field of analyzing tree rings to determine climate

	history. Wide rings indicate warm/wet years; narrow rings indicate cold/dry years.
<b>Eutrophication</b>	The process where excess nutrients (like nitrogen and phosphorus) in a body of water lead to dense algal blooms.
<b>Leachate</b>	The toxic liquid (“garbage juice”) formed when rainwater filters through the waste in a landfill.
<b>Linear Economy</b>	An economic model based on a “Take-Make-Waste” pattern of resource consumption.
<b>Ozone Layer</b>	The region within the stratosphere containing a high concentration of ozone ( $O_3$ ) that protects the Earth from harmful UV-B radiation.
<b>PM2.5</b>	Particulate matter with a diameter of less than 2.5 microns, small enough to bypass the body’s defenses and enter the lungs and bloodstream.
<b>Primary Pollutants</b>	Pollutants that are emitted directly from a source (e.g., soot from a fire).
<b>Proxy Data</b>	Preserved physical characteristics from the past used to reconstruct historical climates (e.g., ice cores, tree rings).
<b>Radon</b>	A colorless, odorless, radioactive gas produced by the natural decay of uranium in soil and rock.
<b>Secondary Pollutants</b>	Pollutants that are formed by chemical reactions in the atmosphere (e.g., ground-level ozone).
<b>Stack Effect</b>	The process where warm air rising inside a home creates a pressure difference that can draw in gases, like radon, from the soil through cracks in the foundation.
<b>Stratosphere</b>	The layer of the atmosphere from approximately 12 km to 50 km in altitude, which contains the ozone layer.
<b>Temperature Inversion</b>	An atmospheric condition where a layer of warm air traps a layer of colder, denser, and often polluted air near the ground.
<b>Troposphere</b>	The lowest layer of the atmosphere (surface to ~12 km), where we live and where all weather occurs.

### 1.3 Section Conclusion

Now that you have reviewed the essential vocabulary, the following summary will show how these individual terms connect to form the larger narrative of our atmosphere, our climate, and our role in its future.

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## 2.0 Core Concepts Summary Outline

### 2.1 Introduction to the Unit Narrative

This section presents the narrative backbone of Unit 4. Understanding these concepts in sequence is key to seeing the bigger picture, from the fundamental composition of our atmosphere to the challenges we face and the innovative solutions we are developing. Following this story will help you logically connect ideas and prepare for questions that require you to synthesize information.

### 2.2 Section 1: The Air We Breathe (ES20-AH1)

- **Atmosphere Composition & Structure:**
  - **Major Gases:**
    - Nitrogen (N<sub>2</sub>): 78%
    - Oxygen (O<sub>2</sub>): 21%
    - Argon (Ar): 0.9%
    - Trace Gases (CO<sub>2</sub>, CH<sub>4</sub>, etc.): 0.1%
  - **Water Vapor (H<sub>2</sub>O):** Varies from 0-4% and is the primary driver of weather.
  - **Layers of the Atmosphere:**
    1. **Troposphere:** Where we live, where all **weather** occurs, and contains **75% of the atmosphere's mass**.
    2. **Stratosphere:** Contains the protective **Ozone Layer**.
    3. **Mesosphere:** The coldest layer, where meteors burn up.
    4. **Thermosphere:** Where the **Aurora Borealis** (Northern Lights) occurs.
    5. **Exosphere:** The outermost layer that fades into space.
- **Air Quality Challenges:**
  - **Pollutant Types:**
    - **Primary Pollutants:** Emitted directly from a source (e.g., soot).
    - **Secondary Pollutants:** Formed by chemical reactions in the air (e.g., ground-level ozone).
  - **Key Saskatchewan Challenges:**
    - **Wildfire Smoke/PM2.5:** Microscopic particles that can enter the bloodstream.
    - **Agriculture:** Dust from fields and ammonia/methane from livestock.
    - **Sour Gas/H<sub>2</sub>S:** Toxic hydrogen sulfide from oil and gas operations, which is dangerous because high concentrations can **deaden the sense of smell**.
  - **Temperature Inversion:** This effect occurs when a layer of warm air traps cold, polluted air near the ground, worsening air quality.
- **Ozone & Radon:**

- **Ozone:** “Good Ozone” in the stratosphere protects us from UV radiation, while “Bad Ozone” at ground level is a harmful component of smog.
- **Critical Misconception:** Ozone depletion does **not** cause global warming. Ozone depletion is about increased UV radiation, whereas global warming is about trapped infrared heat.
- **Radon:** A radioactive gas from the natural decay of uranium in Saskatchewan soil. It enters homes via the “stack effect” and is the second leading cause of lung cancer.

## 2.3 Section 2: Analyzing a Changing Climate (ES20-AH2)

Recall the trace gases that make up just 0.1% of our atmosphere; despite their small quantity, they play an outsized role in regulating Earth’s temperature through the Greenhouse Effect.

- **The Greenhouse Effect:**
  - The natural greenhouse effect is essential for life, acting like a blanket to keep Earth warm enough for life.
  - The **Anthropogenic Greenhouse Effect** is the result of human activities adding extra greenhouse gases, like CO<sub>2</sub>, which is like adding “extra blankets” and trapping too much heat.
- **Geoscience Data (Proxies):**
  - **Proxy Data:** Preserved physical evidence used to reconstruct past climates.
  - **Examples:**
    - **Ice Cores:** Air bubbles trapped in ice sheets provide direct samples of ancient atmospheric gas concentrations, offering a record stretching back **800,000 years**.
    - **Dendrochronology:** The study of tree rings, where wide rings indicate good growing years (warm, wet) and narrow rings indicate poor years (cold, dry).
- **Saskatchewan-Specific Impacts:**
  - **Shifting Hardiness Zones:** Growing seasons are getting longer, but this disrupts natural ecosystems.
  - **Water Security:** Shrinking glaciers in the Rocky Mountains threaten the late-summer water flow of the Saskatchewan River system.
  - **Mountain Pine Beetle:** Warmer winters allow this forest pest to survive and spread eastward from the mountains.
- Each of these impacts—from shifting hardiness zones to the eastward march of the Mountain Pine Beetle—is a direct, observable consequence of the enhanced “extra blankets” of the Anthropogenic Greenhouse Effect.

## 2.4 Section 3: Population, Pollution, and Solutions (ES20-HP1)

- **Waste Management:**
  - Our economy is moving from a **Linear Economy** (Take-Make-Waste) to a **Circular Economy** (Recycle/Reuse), driven by the recognition that raw materials are finite and our capacity to absorb waste is limited.
  - Modern landfills are engineered with clay liners to capture **leachate** (toxic garbage juice) and pipe systems to capture methane gas, which can be used to generate electricity.
- **Biological Nutrient Removal (BNR):**
  - The primary goal of BNR is to remove nitrogen and phosphorus from wastewater to prevent **eutrophication** (damaging algal blooms) in rivers.
  - The City of Saskatoon's plant uses two key bacteria: **Nitrosomonas** and **Pseudomonas**.
- **Carbon Capture and Storage (CCS):**
  - Saskatchewan's **Boundary Dam** project is a world-leading example of CCS.
  - **The Process:**
    1. Exhaust smoke is passed through an **amine solution**, which selectively binds with and captures the CO<sub>2</sub>.
    2. The CO<sub>2</sub> is then separated from the amine solution and **compressed** into a dense, liquid-like state.
    3. The compressed CO<sub>2</sub> is pumped 3.4 km underground into a deep, **porous rock formation** (the Aquistore site) for permanent storage.

## 2.5 Section Conclusion

You have now reviewed the core content of Unit 4. The next step is to apply this knowledge. Use the following practice questions to test your understanding and identify any areas that may require further review.

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## 3.0 Practice Questions

### 3.1 Introduction to Self-Assessment

The most effective way to prepare for an exam is to actively test your knowledge. Attempt to answer all questions in this section *before* looking at the answer key. This process of self-assessment is the best way to discover what you know well and what concepts you need to revisit.

### 3.2 Part A: Fill-in-the-Blank

1. The outermost layer of the atmosphere that fades into the vacuum of space is called the \_\_\_\_.
2. The reflectivity of a surface, such as ice or dark soil, is known as its \_\_\_\_.
3. The toxic “garbage juice” that can contaminate groundwater if it escapes from a landfill is called \_\_\_\_.
4. Data from preserved physical characteristics, such as ice cores and tree rings, is known as \_\_\_\_ data.
5. Ground-level ozone, a key component of smog, is an example of a \_\_\_\_ pollutant because it forms from chemical reactions in the atmosphere.
6. The enhancement of the greenhouse effect by human activities is known as the \_\_\_\_ Greenhouse Effect.
7. The process where bacteria are used to remove nitrogen and phosphorus from wastewater to prevent algal blooms is called \_\_\_\_.
8. Warmer winters in Western Canada have allowed the \_\_\_\_ to survive and spread eastward, posing a threat to Saskatchewan’s forests.
9. The layer of the atmosphere that contains the protective ozone layer is the \_\_\_\_.
10. In Saskatchewan homes, the \_\_\_\_ describes how warm, rising indoor air can create a pressure difference that pulls radon gas in from the soil.

### 3.3 Part B: Short Answer Questions

1. Explain why PM2.5 from wildfire smoke is a significant health risk to humans.
  2. Contrast the environmental problem of stratospheric ozone depletion with the problem of global warming. Be sure to clarify the common misconception between them.
  3. Describe the “stack effect” and explain how it contributes to radon exposure in Saskatchewan homes.
  4. According to the course materials, how do shrinking glaciers in the Rocky Mountains pose a threat to water security in Saskatchewan?
  5. Briefly explain how the Biological Nutrient Removal (BNR) process helps prevent eutrophication in rivers.
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## 4.0 Answer Key

### 4.1 Introduction

Use this key to check your answers from the practice section. For any questions you answered incorrectly, take a moment to review the corresponding concept in the summary outline above.

### 4.2 Answers: Part A (Fill-in-the-Blank)

- |              |                                      |
|--------------|--------------------------------------|
| 1. Exosphere | 6. Anthropogenic                     |
| 2. Albedo    | 7. Biological Nutrient Removal (BNR) |
| 3. Leachate  | 8. Mountain Pine Beetle              |
| 4. Proxy     | 9. Stratosphere                      |
| 5. Secondary | 10. Stack effect                     |

### 4.3 Answers: Part B (Short Answer Questions)

1. **PM2.5** is a significant health risk because its particles are less than **2.5 microns** wide. This microscopic size allows them to bypass the body's natural defenses (like nose hairs and mucus) and travel deep into the **lungs** and even pass directly into the **bloodstream**.
2. These are two separate environmental problems:
  - **Stratospheric ozone depletion** is about the thinning of the ozone layer, which leads to more harmful **UV radiation** reaching Earth's surface, increasing risks of skin cancer and cataracts.
  - **Global warming** is caused by greenhouse gases trapping **infrared heat** in the atmosphere, leading to rising global temperatures.
  - The **misconception** is that the ozone hole causes global warming; they are distinct issues with different causes and effects.
3. The **stack effect** occurs when warm air inside a house rises and escapes through the upper levels. This creates a small pressure difference, like a weak vacuum, in the lower levels of the house (e.g., the basement). This pressure difference can suck in gases from the surrounding soil through cracks in the foundation, which is how radioactive **radon** gas enters homes.
4. Shrinking glaciers in the Rocky Mountains threaten Saskatchewan's water security because they act as a natural reservoir. In the dry, late-summer months like August, meltwater from these glaciers is a critical source of flow for the **Saskatchewan River** system. As the glaciers shrink, this reliable late-season water supply is reduced.
5. **Biological Nutrient Removal (BNR)** prevents eutrophication by using specific bacteria to remove **nitrogen** and **phosphorus** from wastewater. By removing them, BNR prevents massive **algal blooms**. These blooms would otherwise decompose, consume all the dissolved oxygen, and create "**dead zones**" harmful to aquatic life.