NO PREP

Dissolved Gases in Seawater

Oxygen, CO_2, and Nitrogen

Includes: Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

Dissolved Gases in Seawater: Oxygen, CO_2, and Nitrogen

Why Gases Matter in the Ocean

The ocean is not just a salty reservoir of water—it is also a vital storehouse of dissolved gases. Just like air on land contains oxygen, carbon dioxide, and nitrogen, so does seawater. These gases enter the ocean mainly through exchange with the atmosphere, biological activity, and physical mixing. Without them, life as we know it could not exist in marine ecosystems. Oxygen (O_2) is essential for respiration in most marine organisms, from tiny plankton to giant whales. Carbon dioxide (CO_2) plays a dual role: it fuels photosynthesis in phytoplankton but also contributes to acidification when present in excess. Nitrogen (N_2), while relatively

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Oxygen Distribution in the Ocean

Oxygen is produced in the surface ocean through photosynthesis by phytoplankton. Sunlight drives this process, creating oxygen as a by-product. As a result, surface waters are often rich in oxygen. Deeper down, however, oxygen decreases as organisms consume it during respiration and decomposition. This creates what scientists call the oxygen minimum zone (OMZ)—a layer in the mid-ocean where oxygen concentrations are very low. Oxygen is eventually replenished in deep waters through thermohaline circulation, the global "conveyor belt" that brings cold, oxygen-rich waters from the surface into the ocean's depths. This mixing process ensures that even the darkest layers of the sea can support life, though oxygen

levels there are much lower than at the surface. Low-oxygen areas can create serious challenges for marine organisms. Fish and other animals may be forced to migrate, and ecosystems can collapse when oxygen levels fall below critical thresholds. Human activities such as nutrient pollution can make this worse by fueling algal blooms, which deplete oxygen when they decay.

The Role of Carbon Dioxide and Nitrogen

Carbon dioxide is constantly exchanged between the ocean and atmosphere. While phytoplankton absorb CO_2 for photosynthesis, much of it also dissolves into seawater and becomes part of the carbonate buffering system. This makes CO_2 both a necessity for marine life and a driver of ocean acidification when concentrations rise too high. Nitrogen, in contrast, is abundant in its gaseous form but unusable to most organisms. Specialized microbes called diazotrophs can convert nitrogen gas into ammonium (NH_4^+) through nitrogen fixation. This process supplies the ocean with biologically available nitrogen, which is essential for building proteins and DNA. Without nitrogen cycling, ocean ecosystems would not be able to sustain productivity. Together, oxygen, carbon dioxide, and nitrogen form the backbone of marine chemistry. They regulate life processes, shape ecosystems, and even influence the global climate. Understanding how these gases move and change in the ocean is one of the keys to protecting marine life and forecasting environmental change.

Key Information: Table: Dissolved Gases in Seawater

Gas	Primary Source	Role in Ocean Life	Potential Challenges
Oxygen (O_2)	Photosynthesis, atmosphere	Respiration for most marine organisms	Depletion in OMZs and dead zones
CO_2	Atmosphere, respiration	Photosynthesis, buffering system	Ocean acidification
Nitrogen (N_2)	Atmosphere	Nitrogen fixation for nutrient supply	Limited availability unless fixed

Case Study: The Gulf of Mexico "Dead Zone"

Every summer, a massive "dead zone" forms in the Gulf of Mexico near the Mississippi River Delta. This zone is not truly lifeless, but it is severely depleted of oxygen, making it nearly impossible for fish, crabs, and shrimp to survive. The problem begins on land, where fertilizers and other nutrients wash into rivers and flow into the Gulf. These nutrients fuel explosive growth of algae, which eventually die and sink. As bacteria decompose the algae, they consume vast amounts of oxygen, creating hypoxic (low-oxygen) conditions. At its peak, the Gulf dead zone can stretch over 6,000–7,000 square miles—about the size of New Jersey. Fishing communities feel the economic consequences as species migrate away or die off. While natural processes contribute to some variation, the scale of this dead zone is directly tied to human agricultural practices. Reducing nutrient runoff is seen as the key to shrinking its size in the future. This case highlights how dissolved oxygen is not just a scientific concern but also an environmental and economic one. The balance of gases in the ocean connects ecosystems, climate, and human societies in powerful ways.

1. What role do nutrients from land play in creating the Gulf of Mexico's dead zone?

2. How does the dead zone illustrate the link between human activity and dissolved oxygen levels?

Multiple Choice

1. Which factor increases the solubility of oxygen in seawater?

    a) Shallow depth

    b) Higher temperature

    c) Lower salinity

    d) Increased sunlight

2. What is the main cause of the Gulf of Mexico's dead zone?

    a) Fertilizer runoff

    b) Overfishing

    c) Upwelling currents

    d) Oil spills

3. Which organisms can convert nitrogen gas into a usable form?

    a) Coral polyps

    b) Diazotrophic microbes

    c) Phytoplankton

    d) Grazing zooplankton swarms

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ Layer of the ocean with very low oxygen	A) Phytoplankton
2. ___ Photosynthetic organisms producing oxygen	B) Diazotrophs
3. ___ Process that converts N_2 into ammonium	C) Dead zone
4. ___ Nutrient pollution leading to low oxygen	D) Oxygen minimum zone
5. ___ Microbes that carry out nitrogen fixation	E) Nitrogen fixation

Fill-in-the-Blank

1. Cold water can hold more _____ than warm water.

2. Excess _____ in the ocean contributes to acidification.

3. The process of _____ allows nitrogen gas to be converted into usable forms.

Short Answer

Answer each question in 2-4 complete sentences.

1. Why are polar waters typically rich in oxygen compared to tropical waters?

2. How does nutrient pollution create hypoxic conditions in coastal ecosystems?

3. Why is nitrogen fixation essential for supporting marine food webs?