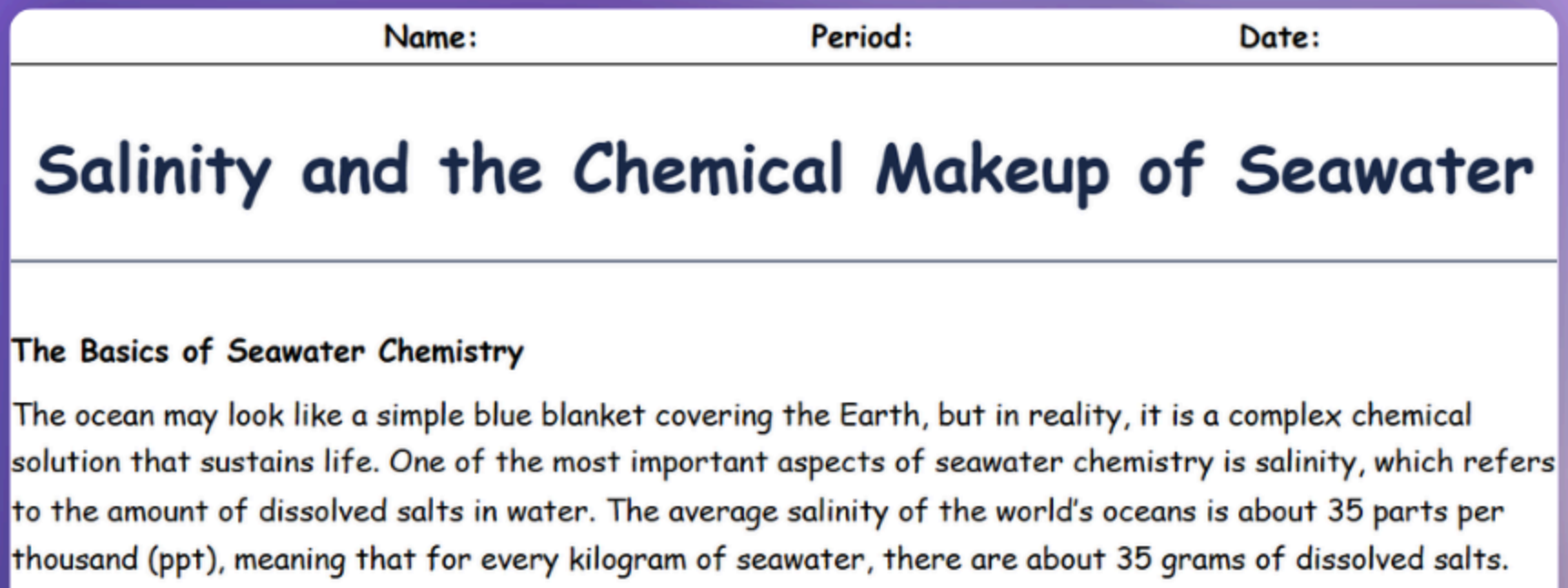
NO PREP

Salinity and the Chemical Makeup of Seawater

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



Name: Period: Date:

Salinity and the Chemical Makeup of Seawater

The Basics of Seawater Chemistry

The ocean may look like a simple blue blanket covering the Earth, but in reality, it is a complex chemical solution that sustains life. One of the most important aspects of seawater chemistry is salinity, which refers to the amount of dissolved salts in water. The average salinity of the world's oceans is about 35 parts per thousand (ppt), meaning that for every kilogram of seawater, there are about 35 grams of dissolved salts.

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The ocean may look like a simple blue blanket covering the Earth, but in reality, it is a complex chemical solution that sustains life. One of the most important aspects of seawater chemistry is salinity, which refers to the amount of dissolved salts in water. The average salinity of the world's oceans is about 35 parts per thousand (ppt), meaning that for every kilogram of seawater, there are about 35 grams of dissolved salts. While this may seem like a small amount, it is enough to create a unique chemical environment that shapes marine ecosystems. The salts in seawater are mostly made up of major ions—including sodium (Na^+), chloride (Cl^-), magnesium (Mg^{2+}), sulfate (SO_4^{2-}), and calcium (Ca^{2+}). These ions are remarkably consistent in their relative proportions no matter where you sample seawater. For example, if sodium makes up about 30% of the ions in one region of the ocean, it will also make up about 30% in another. This principle is called the "Rule of Constant Proportions." It allows scientists to determine salinity by measuring just one ion and then calculating the rest. Salinity is not uniform across the ocean. Some regions, such as the Mediterranean Sea or the Red Sea, have much higher salinity due to strong evaporation and limited freshwater input. In contrast, places like the Baltic Sea or areas near the mouths of large rivers have lower salinity because of high freshwater inflow. These variations in salinity affect density, circulation, and ultimately, the distribution of marine life.

Sources of Salts in the Ocean

Where do these salts come from? Most of the ions in seawater originate from weathering of rocks on land. Rainwater, slightly acidic due to dissolved carbon dioxide, breaks down rocks and minerals. Rivers carry the released ions into the ocean. Another important source is hydrothermal vents, located along mid-ocean

ridges. These vents release dissolved minerals and gases from Earth's crust into seawater. Despite these constant inputs, salinity has remained relatively stable for millions of years. This stability is explained by the concept of a steady state, where the input of salts is balanced by their removal. Salts are removed from the ocean through processes like the formation of evaporite deposits, where salt crystals form in shallow, evaporating basins, or through the incorporation of ions into the shells and skeletons of marine organisms. To understand this balance, scientists compare the residence time of different elements in seawater, or how long they remain before being removed. For instance, sodium has a very long residence time, meaning its concentration in seawater stays steady over geological timescales. In contrast, elements like iron or aluminum have much shorter residence times and can vary significantly.

Biological and Ecological Importance of Salinity

Salinity is not just a chemical curiosity—it plays a vital role in shaping life in the ocean. Many marine organisms are adapted to survive only within certain salinity ranges. For example, stenohaline organisms can tolerate only a narrow range of salinity, while euryhaline organisms—such as salmon—can survive in a wide range, moving between freshwater and seawater during their life cycles. Salinity also influences density-driven circulation, or thermohaline circulation, which helps distribute heat and nutrients around the globe. Areas of high evaporation increase salinity, which makes water denser and causes it to sink. This process contributes to the global conveyor belt, a massive system of currents that regulates Earth's climate. Understanding salinity also helps scientists track climate change. Rising global temperatures may change patterns of precipitation, evaporation, and ice melt, all of which influence salinity. Tracking these changes provides clues to how ocean chemistry and circulation might shift in the future. This distribution remains constant across the world's oceans, showing the remarkable chemical stability of seawater.

Key Information: Table: Major Ions in Seawater

Ion	Symbol	Approximate % of Total Salts
Chloride	Cl^-	55%

Ion	Symbol	Approximate % of Total Salts
Sodium	Na^+	30%
Sulfate	SO_4^{2-}	7.7%
Magnesium	Mg^{2+}	3.7%
Calcium	Ca^{2+}	1.2%
Potassium	K^+	1.1%

Case Study: The Dead Sea – An Extreme Example of Salinity

The Dead Sea, located between Israel and Jordan, provides a striking case study in salinity. With a salinity of over 300 ppt, it is almost ten times saltier than the average ocean. Unlike the open ocean, the Dead Sea has no outlet. Rivers, especially the Jordan River, bring in water carrying dissolved salts and minerals. However, the only way water leaves is through evaporation, which leaves the salts behind. Over thousands of years, this process has concentrated salts to extreme levels. The high salinity makes the Dead Sea uninhabitable for most organisms, hence its name. Fish and aquatic plants cannot survive in such a salty environment. Only specialized microorganisms, such as halophilic (salt-loving) bacteria, can live there. The density of the water is so high that people can easily float without sinking, a popular tourist attraction. The Dead Sea also provides scientists with insight into how evaporation, climate, and geology can dramatically alter the chemistry of a body of water. It demonstrates what might happen to parts of the ocean if the balance between salt input and output were disrupted.

1. Why is the Dead Sea much saltier than the open ocean?

2. How does the Dead Sea illustrate the concept of steady state being disrupted?

Multiple Choice

1. What is the average salinity of seawater?

    a) 50 ppt

    b) 25 ppt

    c) 35 ppt

    d) 15 ppt

2. Which process adds salts to the ocean?

    a) Hydrothermal vents

    b) Photosynthesis by ocean organisms

    c) Respiration

    d) Evaporation

3. Which organisms can tolerate only narrow ranges of salinity?

    a) Halophilic microbes

    b) Stenohaline

    c) Euryhaline

    d) Planktonic

Matching

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

Term	Definition
1. ___ The most abundant ion in seawater	A) Euryhaline organisms
2. ___ The principle that major ions remain constant	B) Residence time
3. ___ Organisms adapted to wide salinity ranges	C) Steady state
4. ___ Balance between salt input and output	D) Rule of Constant Proportions
5. ___ How long an element remains in seawater	E) Chloride

Fill-in-the-Blank

1. The process of _____ breaks down rocks on land and delivers ions to the ocean.

2. The Dead Sea is nearly ten times saltier than the _____.

3. The movement of water driven by density and salinity is called _____ circulation.

Short Answer

Answer each question in 2-4 complete sentences.

1. Why does salinity vary between regions such as the Baltic Sea and the Red Sea?

_____

_____

_____

2. How does salinity influence the global conveyor belt?

3. Why are chloride and sodium considered "conservative" elements in seawater?