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| **Lesson Title** | Greenhouse Gases: Political Debate or Real Science? |
| **Length of Lesson** | 40 minutes |
| **Created By** | Erin Anderson |
| **Subject** | Chemistry |
| **Grade Level** | 9-12 |
| **State Standards** | 2C, 5B, 13A |
| **DOK Level** | IV |
| **DOK Application** | Apply Concepts, Create. |
| **National Standards** | B. Physical Science |
| **Graduate Research Element** | Gas exchange between soil/sediments, water bodies, and the atmosphere occurs all the time. The volatization of some gases affect the between the sediments and marine waters are not always healthy. In my research, I concentrate on the gas exchange of sulfate (oxidized) and sulfide (reduced), because high levels of sulfide are toxic to sea plants and animals. |

**Student Learning Goal:** Non-symmetric gas molecules trap energy (heat) from the sun more effectively than symmetric molecules.

**State Standards:**
2C. Apply the definition of mass, length, volume, time, density, temperature and pressure.
5B. Identify simple molecules as polar or non-polar on the basis of molecular shape and bond polarity.
13A. Compare properties of acids and bases, including how they affect indicators and the relative pH of the solution.

**National Standards: B. Physical Science: Interactions of Energy and Matter**

- Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

**Materials Needed (supplies, hand-outs, resources):** 1 pack sandwich ziploc bags (at least 20), $CH_4$ (gas jets), $CO_2$ (tank), Nitrogen (just use atmosphere), 6 thermometers, bromothymol blue indicator, 20 straws, (5) 250 ml beakers, 75 ml tap water, colored straws.

**Lesson Performance Task/Assessment:**

(1) How does carbon dioxide gas in our atmosphere affect the pH of water? Students will fill beakers with tap water and add a few drops bromothymol blue indicator to the water. Students will exhale through straws into the water, hopefully saturating the water with carbon dioxide. The color of the water should change to yellow, indicating that dissolved carbon dioxide lowers of the pH of the solution.

(2) Each group will have 3 bags of gases (nitrogen, carbon dioxide, methane). Tubes connecting the Ziploc bags and tanks of the respective gases will fill the Ziploc bags. They will set the bags out in front of the school. For every minute, take a thermometer reading of the bag and record results for a total of 10 minutes. Discuss results and differences in temperature between the gases.

**Lesson Relevance to Performance Task and Students:**
Gas exchange occurs all the time between the atmosphere and water bodies (salt and fresh). Understanding how dissolved gases affect water quality and atmospheric quality are important, because animals are easily affected by water quality and atmospheric quality changes, for better or worse. Nothing is steady-state on our planet. We need to be aware of how changes affect our environment, so we can reduce hazardous gas exchanges that occur all the time.

**Anticipatory Set/Capture Interest:** Watch a youtube video on methane volatilization to prepare the class. Did Dinosaurs Cause Global Warming? By geobeats. Link: http://www.youtube.com/watch?v=Ry-lu5l1wRA

**Guided Practice:**
Discussion of atmospheric gases and their origins.

- Where did the gases in our atmosphere come from? *Gas exchange between soils, oceans, lakes, the atmosphere, and reactions from light interactions contribute to constant fluxing between these environments.*
- Are the levels of specific gases constant? *No, some reactions occur more frequently and/or faster at certain parts of year or even over the course of the day. Example: Evapotranspiration rates are lower in winter, because the plants are less active in drawing water through their roots and doing photosynthesis. Less oxygen is released into the atmosphere from plants during the winter.*

**Independent Practice:** Students will measure the pH of their own carbon dioxide water solutions and record their results. Students will be divided into groups, and they will record the temperature changes of each gas as it warms in the sunshine.

**Remediation and/or Enrichment:** All IEP's will be supported. For remediation, I will explain concepts of symmetry and how polarity affects the geometry of the bonds. For enrichment, I will discuss how microorganisms play a part in gas exchange.

**Check(s) for Understanding:**

1. How does $CO_2$ dissolution in water affect water pH?
2. How do you think gas exchange affects the atmosphere? The ocean? Explain your reasoning with an example.
3. Does the symmetry of the molecule affect the amount of temperature increases with time?
4. Did your expectations match your results?

**Closure:** Students will present their temperature findings and attempt to explain which gas traps the most heat and which gas traps the least amount of heat, using the correct vocabulary (words like symmetry, geometry, double-and-triple bonds).

**Possible Alternate Subject Integrations:** Earth Science, History

**Teacher Notes:**
Wings for Learning: The Atmosphere/Driving Forces. The Educational Film Center in association with the University of Maryland.

Directions for making solutions and filling bags with different gases are located in **Lesson Performance Task/Assessment**.