**Atmospheric Chemistry Unit: Lesson Two**

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| **Title** | Climate Change Research | | | |
| **Introduction** | Scientific research supports the existence of global climate change. Global temperatures are rising consistently, but the specific causes are unknown. Identification of greenhouse gases aroused suspicion that the rising temperatures are a result of anthropogenic influences on the environment. In this lesson, students will research global climate change to determine the environmental effects of a specific greenhouse gas. Students will then design an experiment to reduce their emissions of the greenhouse gas. | | | |
| **Learning Outcomes** | 1. Students will be able to describe climate change and global warming in terms of the scientific and social impacts. 2. Students will be able to design an experiment to test their level of impact on the emissions of a specific gas. 3. Students will be able to devise a plan to lower their emissions of that specific gas. | | | |
| **Curriculum Alignment** | North Carolina Standard Course of Study (NCSCOS)  **CHEMISTRY**  **Standard 1.1**: Students will analyze the structure of atoms and ions.  1.1.3: Explain the emission of electromagnetic radiation in spectral form in terms of the Bohr Model.  **Standard 3.2**: Students will understand solutions and the solution process.  3.2.1: Classify substances using the hydronium and hydroxide ion concentrations.  3.2.3: Infer the quantitative nature of a solution (molarity, dilution, and titration with a 1:1 molar ratio).  **PHYSICS**  **Standard 2.2**: Analyze the behavior of waves.  2.2.1: Understand the meaning of wavelength, period, frequency, amplitude, and wave velocity.  2.2.2: Analyze wave behaviors in terms of transmission, reflection, refraction, and interference.  2.2.3: Compare sound and light in terms of wave characteristics and behavior.  **EARTH/ENVIRONMENTAL SCIENCE**  **Standard 2.2**: Explain how human influences impact the lithosphere.  2.2.2: compare various methods humans use to acquire traditional energy sources (such as peat, coal, oil, natural gas, nuclear fission, and wood).  **Standard 2.5**: Understand the structure of and processes within our atmosphere.  2.5.5: Understand how acid rain is formed.  **Standard 2.6**: Analyze patterns of global climate change over time.  2.6.2: Explain changes in global climate due to natural processes (El Nino/La Nina, volcanic eruptions, sunspots, shifts in Earth’s orbit, and carbon dioxide fluctuations).  2.6.3: Analyze the impacts that human activities have on global climate change (such as burning hydrocarbons, greenhouse effect, and deforestation).  **BIOLOGY**  **Standard 4.2**: Students will understand the impact of human activities on the environment (one generation affects the next).  4.2.1: Infer how human activities may impact climate change. | | | |
|  | International Baccalaureate Curriculum  **Standard 2.2**: The Mass Spectrometer  2.2.1: Describe and explain the operation of a mass spectrometer.  2.2.2: Describe how the mass spectrometer may be used to determine relative atomic mass using the 12C scale.  2.2.3: Calculate non-integer relative atomic masses and abundance of isotopes from given data.  **Standard E1**: Air Pollution  E1.1: Describe the main sources of carbon monoxide (CO), oxides of nitrogen (NOx), oxides of sulfur (SOx), particulates and volatile organic compounds (VOCs) in the atmosphere.  E1.2: Evaluate current methods for the reduction of air pollution.  **Standard E2**: Acid Deposition:  E2.1: State what is meant by the term acid deposition and outline its origins.  E2.2: Discuss the environmental effects of acid deposition and possible methods to counteract them.  **Standard E3**: Greenhouse Effect  E3.1: Describe the greenhouse effect.  E3.2: List the main greenhouse gases and their sources, and discuss their relative effects.  E3.3: Discuss the influence of increasing amounts of greenhouse gases on the atmosphere.  **Standard E4**: Ozone Depletion  E4.1: Describe the formation and depletion of ozone in the stratosphere by natural processes.  E4.2: List the ozone depleting pollutants and their sources.  E4.3: Discuss the alternatives to CFCs in terms of their properties.  **Standard E9**: Ozone Depletion  E9.1: Explain the dependence of O2 and O3 dissociation on the wavelength of light.  E9.2: Describe the mechanism in the catalysis of O3 depletion by CFCs and NOx.  E9.3: Outline the reasons for greater ozone depletion in polar regions.  **Standard E10**: Smog  E10.1: State the source of primary pollutants and the conditions necessary for the formation of photochemical smog.  E10.2: Outline the formation of secondary pollutants in photochemical smog.  **Standard E11**: Acid Deposition  E11.1: Describe the mechanism of acid deposition caused by the oxides of nitrogen and oxides of sulfur.  E11.2: Explain the role of ammonia in acid deposition. | | | |
| **Classroom Time Required** | One 90-minute period | Two 45-minute periods | | Eight weeks of work outside of class |
| **Materials Needed** | * Research data for a specific greenhouse gas * Reference materials for determining the impact of each gas on the environment * Various lab materials as determined by the students | | | |
| **Technology Resources** | * One computer with internet access for every two students * Microsoft Word * Microsoft PowerPoint | | | |
| **Pre-Activities** | For Teachers   * Divide students into groups of 4. Each group of 4 should contain one student from each of the following classes: chemistry, biology, physics, and environmental science. * Assign a specific greenhouse gas to each group and print out the sample research data for that gas. * Research each greenhouse gas that is assigned to the student groups. Have ideas as to what types of experiments students may do to reduce their emissions of the greenhouse gas. | | For Students   * Required prerequisite classes: Biology, Chemistry * Optional prerequisite classes: Physics, Environmental Science * Gather contact information from each student in the group. * Plan weekly group meetings to work on the project. * Research the assigned greenhouse gas to determine what increases its emissions. | |
| **Activities** | Assignment and Research of Greenhouse Gases | | | |
| For Teachers | | For Students | |
| * Assign each student group a greenhouse gas. (This should be the same gas they used for the research data calculations.) * Circulate through the room to help students design their experiments. | | * Research the assigned greenhouse gas to determine the origin of the emissions. * Begin designing an experiment to reduce emissions of the assigned greenhouse gas. | |
| Design an Experiment to Reduce Emissions of Your Greenhouse Gas | | | |
| For Teachers | | For Students | |
| * Possible experiments:   + Mowing lawns with reel mowers rather than push mowers to reduce CO2   + Carpooling to reduce CO2   + Recycling cans to reduce SF6   + Painting roofs white to reduce H2O * Students must have a way to collect quantitative data. The teacher may need to help students recognize ways to incorporate quantitative elements into their experiment. * The experiments should be conducted outside of school and will take around 10 weeks to finish. | | * Design an experiment to reduce the emissions of your particular greenhouse gas.   + Students may need to do more research to determine what emits their greenhouse gas. * Conduct the experiment and record quantitative data. Analyze the data to show that the emissions have either been reduced, increased, or unchanged. * The experiments should be conducted outside of school and will take around 10 weeks to finish. | |
| **Assessment** | The teacher will read the experiments designed by the student groups. These procedures should include evidence that the students understand the greenhouse gas with which they are working. For example, if a student group designs an experiment to reduce emissions of NO2, but their experiment does not address the reduction of NO2 emissions, then the students do not understand the significance and impact of their particular gas. | | | |
| **Modifications** | This lesson can be modified to meet students of lower ability levels. Instead of having the students design their own experiment, the teacher could give the students several different experiments from which to choose. These experiments could be done in class with teacher supervision. | | | |
| **Alternative Assessments** | The teacher could assess the students’ abilities to research and learn material about specific greenhouse gases. | | | |
| **Supplemental Information** | Extra credit may be given for students who get in contact with officials in the city or county government who may be able to help them with their project. Some students may be able to visit city facilities to view the current efforts made by the city to reduce greenhouse gas emissions. The teacher should encourage students to make these types of contacts. | | | |
| **Critical Vocabulary** | * Anthropogenic: (from the Greek meaning manmade) effects, processes or materials are those that are derived from human activities, as opposed to those occurring in biophysical environments without human influence | | | |
| **Websites and Resources** | <http://www.esrl.noaa.gov/>  <http://www.energy.appstate.edu/docs/devguide_v3.pdf> | | | |
| **Comments** | Students generally enjoy this lesson because it allows them to create their own experiment. They will complain about how much work they have to do, but they eventually take ownership of the project and enjoy improving the atmosphere in their city. | | | |
| **Author Info** | This lesson was written by Kathleen Eckersley. She teaches Chemistry, Honors Chemistry, AP Chemistry, IB Chemistry, and serves as the IB Coordinator at High Point Central High School in High Point, NC. She has been teaching for five years and has a M.A. Ed. in Science from Wake Forest University as well as a B.A. in Chemistry from Baylor University. This project was developed as a part of the Kenan Fellowship through NC State University. Ms. Eckersley spent two summers conducting research with a Cavity Ringdown Spectrometer and developed this curriculum as a result of her research. She did most of her work under the direction of Dr. Keith Schimmel at NC A&T University. | | | |