**Atmospheric Chemistry Unit: Lesson One**

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| **Title** | Introduction to Climate Change | | | |
| **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 and analyze research data from a NOAA laboratory to determine the presence of a specific greenhouse gas in the atmosphere. This lesson is designed to be used across the science curriculum and have students from Biology, Chemistry, Earth/Environmental Science, and Physics working together for 10 hours outside of class each week. If it is not possible to work across the science curriculum, then this lesson could be used in a single classroom if groups are selected to include some knowledge of Biology, Chemistry, Earth/Environmental Science, and Physics in each group. | | | |
| **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 analyze research data to determine the specific gas and its concentration. 3. Students will be able to explain why the presence of a particular gas is detrimental to our environment | | | |
| **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** | Two 90-minute class periods | Or | | Four 45-minute Class Periods |
| **Materials Needed** | * Global Warming: The Signs and the Science (video) * NOAA articles on climate change (See Websites and Resources ) * “Economic Developer’s Guide to Renewable Energy” (File attached) * The teacher should make a “Favorites” folder on Internet Explorer that has all the internet sites needed for this project. * Sample research data (Files attached) | | | |
| **Technology Resources** | * One computer with internet access for every two students * DVD player * LCD projector * Global Warming: The Signs and the Science * Microsoft Word * Microsoft PowerPoint | | | |
| **Pre-Activities** | For Teachers   * Read the NOAA articles on climate change and the “Economic Developer’s Guide to Renewable Energy” * Watch Global Warming: The Signs and the Science and identify any sections where you may want to pause the video for discussion and reflection. * Practice analyzing the sample research data to ensure you understand how to do the calculations. * Divide students into groups of 4. Each group of 4 should contain one student from each of the following classes if this project is run with combined classes: chemistry, biology, physics, and environmental science. If this project is run in a single classroom, choose groups so that there is a mix of skills in each group. * Assign a specific greenhouse gas to each group and print out the sample research data for that gas. | | For Students   * Required prerequisite classes: Biology, Chemistry * Optional prerequisite classes: Physics, Environmental Science | |
| **Activities** | Climate Change and Global Warming Discussion | | | |
| For Teachers   * Sample Discussion Questions:   + What is climate change?   + *Answer: Climate change refers to the increase in average global temperature.*   + Is climate change really happening?   + *Answer: Climate change is a scientifically proven fact. we do not know what is causing the current warming trend.*   + What causes climate change?   + *Answer: Throughout history, the average global temperature has changed consistently. The earth has experienced periods of extremely cold temperatures as well as extremely warm temperatures. Since the earth has a history of average global temperature fluctuation, the cause of our current global warming is unknown. It is possible that the earth is experiencing a natural warming trend. It is also possible that the increased presence of greenhouse gases has caused the average global temperature to increase.*   + Do humans have any influence on global climate change?   + *Answer: Humans may have an influence on global warming due to the increased emission of greenhouse gases.*   + What are greenhouse gases and what do they do?   + *Answer: Greenhouse gases are atmospheric gases that trap warm air and cause the average temperature on Earth’s surface to increase.*   + What are some examples of greenhouse gases?   + *Answer: CO2, CO, H2O, N2O, NO2,SO2, NO, CH4, SF6, O3*   + Do humans have any influence on the release of these greenhouse gases?   + *Answer: Certain products produce greenhouse gases. For example, cars produce CO2, CO, and N2O. Therefore, driving less frequently or carpooling would reduce the emissions of these gases.*   + How do greenhouse gases affect the environment?   + *Answer: They build up in the atmosphere and cause the average global temperature to increase.*   + What can we do to reduce emissions of greenhouse gases?   + *Answer: That is what this project is all about! Once we finish this project, we will have several strategies for reducing emissions of most greenhouse gases.* * It is possible that students may not know the answers to these questions. If students cannot answer the questions, give them 5 – 10 minutes to research the answers. Then, bring the students back together to finish the discussion. | | For Students   * Students should answer the teacher’s questions. If students do not know the answers, it is okay for them to research the answers on the computer. * Each student group could be given a question to research in order to make the discussion happen more quickly. | |
| Watch Global Warming: The Signs and the Science | | | |
| For Teachers | | For Students | |
| * Put the video in the DVD player. Start the video. * Circulate the classroom to make sure students pay attention to the video. * Ask students to reflect on what they have seen after the video is over. | | * Watch the video and take notes. * Offer any reflections on the content of the video when the video ends. | |
| Read NOAA articles and “Economic Developer’s Guide to Renewable Energy” | | | |
| For Teachers | | For Students | |
| * Place students in the pre-determined groups of 4. * Make sure students are on the correct websites to read the required materials.   + Students should read these articles to get a better understanding of global warming and climate change. | | * Swap contact information with each student in the group * Plan weekly group meetings to work on the project. * Read the articles and take notes. | |
| Class Calculation of Sample Data | | | |
| For Teachers | | For Students | |
| * Pass out the Sample Data handout and the graph of the Example Data from the Microsoft Excel file. * Show students where I0 is on the graph. (See attached example of sample data with important data points labeled.) * Ask students to calculate I0/e. * Label I0/e on the graph. * Show students how to locate  and 0 on the graph. * Show students how to solve the equation on the Sample Data handout for . * Match the calculated value for  to the actual values in the chart on the Sample Data handout. * Identify the greenhouse gas in the Sample Data. | | * Read the Sample Data handout and the graph of the Example Data from the Microsoft Excel file. * Label I0 on the graph. * Calculate I0/e. * Label I0/e on the graph. * Locate  and 0 on the graph. * Solve for . * Match the calculated value for  to the actual values in the chart on the Sample Data handout. * Identify the greenhouse gas in the Sample Data. | |
| Group Calculation of Research Data | | | |
| For Teachers | | For Students | |
| * Give each group a different graph of a greenhouse gas from the Microsoft Excel file. * Instruct students to use the same procedure to analyze this data as the procedure used in analyzing the Sample Data. * Circulate the room to help student groups analyze their data. If needed, steer students in the correct direction. | | * Use the same procedure as was used on the Sample Data to analyze the Research Data given by the teacher. * Identify the greenhouse gas in the Research Data. * Students will begin to brainstorm possible procedures to test. These procedures will be due to the teacher for approval tomorrow. | |
| **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 analyze the research data to discover what gas they have, the teacher could simply assign a greenhouse gas to each student group. In addition, 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 give students a grade based on their ability to find the correct greenhouse gas from the Research Data. The teacher could also assess the students’ abilities to research and learn material about specific greenhouse gases. | | | |
| **Supplemental Information** | Watch the video of the Cavity Ringdown Spectrometer. This will give you an idea of how the Research Data was generated. If there is time, the teacher could also show this video in class. | | | |
| **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. | | | |