Lesson Title	The Chemistry of Climate Change
Length of Lesson	180 min
Created By	David Wilson
Subject	Physical Science / Chemistry / Organic Chemistry
Grade Level	8-12
State Standards	2c, 4d / 2a, 4d / 2b, 2c
DOK Level	DOK 2, DOK 2 / DOK 1, DOK 2 / DOK 1, DOK 2
DOK Application	Describe, Utilize / Classify, Explain / Relate, Apply
National Standards	K-12: Unifying Concepts and Processes
Graduate Research Element	Solution concentrations, bond stretches, IR spectroscopy, and energy transformations are all fundamental to chemistry and all other physical sciences.

Student Learning Goal:

State Standards: (Physical Science)

2) Describe and explain how forces affect motion.

c. Describe (with supporting details and diagrams) how the kinetic energy of an object can be converted into potential energy (the energy of position) and how energy is transferred or transformed (conservation of energy). (DOK 2)

4) Develop an understanding of the atom.

d. Utilize the periodic table to predict and explain patterns and draw conclusions about the structure, properties, and organization of matter. (DOK 2)

State Standards: (Chemistry)

2) Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding.

a. Describe and classify matter based on physical and chemical properties and interactions between molecules or atoms. (DOK 1)

4) Analyze the relationship between microscopic and macroscopic models of matter.

d. Explain the thermodynamics associated with physical and chemical concepts related to temperature, entropy, enthalpy, and heat energy. (DOK 2)

State Standards: (Organic Chemistry)

2) Demonstrate an understanding of the properties, structure, and function of organic compounds.

b. Relate structure to physical and chemical properties of hydrocarbon. (DOK 1)

c. Apply principles of geometry and hybridization to organic molecules. (DOK 2)

National Science Standards: (K-12)

Unifying Concepts and Processes:

As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement
- Evolution and equilibrium
- Form and function

National Science Standards: (5-8)

B: Physical Science: Transfer of Energy

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
- Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye.
- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

D: Earth Science: Structure of the Earth System

- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.
- Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

D: Earth Science: Earth in the Solar System

- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.

F: Science in Personal and Social Perspectives: Personal Health

- Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

F: Science in Personal and Social Perspectives: Natural Hazards

- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.
- Natural hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

F: Science in Personal and Social Perspectives: Science and Technology in Society

- Science influences society through its knowledge and worldview. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.
- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.

National Science Standards: (9-12)

B: Physical Science: Structure and Properties of Matter

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.
- The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

B: Physical Science: Chemical Reactions

- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.
- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. 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.

B: Physical Science: Conservation of Energy and the Increase in Disorder

- The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.
- Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

B: Physical Science: Interactions of Energy and Matter

- Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.
- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.
- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

B: Earth and Space Science: Energy in the Earth System

- Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.
- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.
- Global climate is determined by energy transfer from the sun at and near the earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the earth's rotation, and static conditions such as the position of mountain ranges and oceans.

F: Science in Personal and Social Perspectives: Environmental Quality

- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.
- Materials from human societies affect both physical and chemical cycles of the earth.
- Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

F: Science in Personal and Social Perspectives: Natural and Human-Induced Hazards

- Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.
- Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

F: Science in Personal and Social Perspectives: Science and Technology in Local, National, and Global Challenges

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.
- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions—"What can happen?"—"What are the odds?"—and "How do scientists and engineers know what will happen?"
- Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil, and water.

Materials Needed (supplies, hand-outs, resources):

Be Careful and always read the Materials Safety Data Sheet (MSDS) written for chemicals you use. Federal Law requires the vendors of chemicals to provide MSDS sheets for all their chemicals

(All quantities specified here are for approximately one lab group.)

*****PLEASE SEE TEACHER NOTES. The materials for the presented experiments are generally the same, but they differ enough to prevent me giving you a specific list. Each website which lists an experiment contains a detailed materials list.**********

Lesson Performance Task/Assessment:
Students will

- Describe how energy is related to electromagnetic radiation.
- Observe the effect of absorption of EMR on chemical bonds: single, double, and triple.
- Describe different energy transformations.
- Explain how and which types of solutions are represented in the atmosphere.
- Calculate ppm and other concentration units.
- Determine the extent to which relatively pure CO_2 has a higher IR absorption than air.
- Describe the ways in which humanity can and has affected the effective concentration of CO_2 in the atmosphere.

Day 1:

Lesson Relevance to Performance Task and Students:
Students will learn how solar EMR emission, IR absorption, energy transformation, atmospheric systems, net carbon dioxide emissions, and the Greenhouse Effect are related. This first day is focused on learning about EMR, IR absorption by bonds, photochemical reactions, and solutions (in the atmosphere and concentrations thereof.)

Anticipatory Set/Capture Interest:
I will show the students how light can initiate chemical reactions as a way of introducing the effect of EMR on chemicals in general. **I will be sure they do not associate the radical reaction I use with the Greenhouse Effect. Ozone depletion, which is related to radical reactions, is not directly related to the Greenhouse Effect.** I will use the photochemical reaction of hydrogen gas with chlorine gas. (See the Teacher's Notes.)

Guided Practice:
Students will be asked to perform calculations with the equation relating energy to EMR: $E = \upsilon/\lambda$. They will also be required to calculate the ppm of several solutions.

Independent Practice:
This will come on Day 2.

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: This will come on Day 2 also.

Check(s) for Understanding:
Students should be able to perform the required calculations.

Closure:
This will come on Day 2.

Possible Alternate Subject Integrations:
None.

Teacher Notes:
On Day 1, I will discuss EMR, IR spectroscopy, IR bond stretching, energy transformations, solution concentrations, and the types of solutions found in the atmosphere.

These are some references with which these topics can be discussed:
General Reference:

1) http://www.camelclimatechange.org/resources/view/169920/

EMR in General:

1) http://youtu.be/4ntaDE_RHQ4
2) http://youtu.be/kfS5Qn0wn2o
3) http://youtu.be/pWlukTTVavg (Disney Spectrum Song)
4) http://youtu.be/bjOGNVH3D4Y (another song)
5) http://youtu.be/snNwE6txxP0 (NASA)

EMR and the Atmosphere:

1) http://youtu.be/3bbC87CMXwQ

Manipulative Applets:

1) http://www.kcvs.ca/site/projects/chemistry.html (very good site.)

Infrared Spectroscopy in General:

1) http://youtu.be/y4uyx-u5n7Q (video game)

Infrared Spectroscopy – Bond Stretches:

1) http://en.wikipedia.org/wiki/Infrared_spectroscopy
2) http://www.learnerstv.com/animation/animation.php?ani=56&cat=Chemistry
3) http://youtu.be/QZGlhEU-YQg
4) http://youtu.be/3RqEIr8NtMI (old, but good video)
5) http://youtu.be/1uE2lvVkKW0
6) http://youtu.be/6s0b_keOiOU (water melting)
7) http://youtu.be/CDTZoFGmZoc (water melting 2)
8) http://youtu.be/xITzGUjongU (includes CO2)

Day 2:

Lesson Relevance to Performance Task and Students:
Today, students will build a simulated atmosphere and investigate the effect of infrared exposure on a vessel of relatively pure CO_2 and a vessel of air. The students will be able to discuss the chemical properties involved in the Greenhouse Effect.

Anticipatory Set/Capture Interest:
Today is a lab, so THAT in itself is motivational and captures interest. We will briefly discuss how yesterday's lesson will relate to this lab.

Guided Practice:
Building the apparatus will be guided.

Independent Practice:
Manipulating the experimental design will be up to the students. They will be required to insure that the simulated atmosphere they build and the data they take from it allows them to soundly draw conclusions about the effect of CO_2 concentration on the Greenhouse Effect.

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: Students will be expected to draw from lessons learned in former biology classes in order to relate the Greenhouse Effect to the water and carbon cycles. They will be required to hypothesize how these cycles might be disrupted in such a way to exacerbate the Greenhouse Effect, and what might be done to mitigate the effects of this exaggerated Greenhouse Effect.

Check(s) for Understanding:
I will check the students apparatus, and they will be required to write in paragraph form exactly what they did in their experimental procedure and what data they took. They will also be required to submit a formal lab report describing the background that was covered on Day 1 and the experiment performed on Day 2.

Closure:
We will discuss as a class the effect of interjecting politics into scientific findings and the effect of interjecting science into political discussions. We will focus on how this relates to the climate change "debate".

Possible Alternate Subject Integrations:
Political Science. Biology.

Teacher Notes:

The experimental procedure for this lab varies a great deal depending on the source. There are several listed for you to choose from.

My favorite:

1) http://www.espere.de/Unitedkingdom/water/uk_watexpgreenhouse.htm

NASA lesson:

1) http://glory.gsfc.nasa.gov/globalwarmingexperiment.html

NOAA lesson:

1) http://www.pbs.org/wgbh/nova/teachers/viewing/0302_03_nsn.html

Others:

1) http://www.fofweb.com/Onfiles/SEOF/Science_Experiments/1-15.pdf
2) http://www.picotech.com/experiments/global/globalwarming.html
3) http://www.beloit.edu/sepm/Geology_and_the_enviro/Earth_warming.html