AP* ENVIRONMENTAL SCIENCE

CLIMATE CHANGE

Student Packet

A. STRATOSPHERIC OZONE

FORMATION: Free diatomic oxygen (O_2) is transformed into ozone (O_3) in the presence of ultraviolet light. This process occurs in the stratosphere. This stratospheric ozone layer then filters over 90% of UV radiation from the Sun. This ozone is called "good" ozone because of its UV filtering effect.

DEPLETION: Manmade organic compounds known as **chlorinated flurocarbons.** CFC's react with the stratospheric ozone and destroy it chemically. A single CFC molecule can destroy 50,000 ozone molecules. In this way, our protective stratospheric ozone has been depleted. CFC's were the compounds of choice in refrigerators and air conditioners for decades but their use has been banned in the United States.

EFFECTS: Large holes in the protective ozone layer were detected by satellite imagery during the 1990's. These holes would pulsate in size with the seasons and the hole over Antarctica would equal or exceed Antarctica's size during the Austral Summer. UV damages DNA in all life forms. Over exposure to UV radiation can cause skin cancer (malignant melanoma). It is known to cause increased skin cancer rates in humans, it damages the retinas of mammals, and it is suspected currently to be causal in worldwide reef recession and even blindness in sheep at high latitudes. Stratospheric ozone thinning has also been detected in the upper latitudes of the northern and southern hemispheres.

STRATEGIES FOR REDUCING OZONE DEPLETION: CFC's have been banned in most industrialized countries. They were widely used as propellants in canned aerosols. They are also very effective cleaners of computer circuit boards. Other countries failed to implement CFC bans or began to use alternative propellants, many of which are also effective greenhouse gases. CFC's also continue to leak into the atmosphere from junked cars and refrigerators. Additionally, developing countries continue to produce CFC's which exacerbates the stratospheric ozone depletion problem. The **Montreal Protocol** was signed in 1987 in which signees agreed to a 50% reduction if CFC use by 1998.

CFC'S AND OZONE DEPLETION CHEMISTRY FOR HIGH SCHOOL STUDENTS
http://www.ausetute.com.au/cfcozone.html

SATELITE IMAGES OF THE O_3 HOLE
http://images.google.com/images?q=OZONE+HOLES&um=1&ie=UTF-8&ei=1zGbSZidKIH8tgedoZybCw&sa=X&oi=image_result_group&resnum=4&ct=title

MONTREAL PROTOCOL
http://www.undp.org/chemicals/montrealprotocol.htm

B. GLOBAL WARMING

Greenhouse gases are those compounds existing in a vapor phase, both naturally occurring and manmade, that store thermal energy or let solar energy reach the surface of the Earth and/or then prevent its radiation back into space. Carbon dioxide (CO_2), methane (CH_4) and water vapor (H_2O) are good examples of greenhouse gases.

The **Greenhouse Effect** occurs on Earth much like the micro climate of a greenhouse. Incoming solar energy is partially reflected off cloud tops due to their high **albedo** (reflectivity) but much of the energy (average about 1340 Watts per square meter: note **energy per unit area**) is absorbed by the Earth. Much of this transforms water in the oceans from liquid to vapor phase and this vapor represents stored energy. The water vapor also traps thermal energy near the surface of the Earth. This water vapor eventually condenses on dust nuclei to form the water droplets that form clouds which inhibit the radiation of energy from Earth back into space. This leads to rising temperatures which in turn leads to greater evaporation of water, which causes more heat entrapment. This is an example of a **positive feedback mechanism**.

Anthropogenic (manmade) greenhouse gases include CO_2, nitrous oxide and ground level (tropospheric) ozone (due to the burning of fossil fuels) and CFC's. These also serve to trap energy near the surface of the Earth. This energy is then radiated as infrared radiation which is absorbed by the gases previously mentioned.

Impacts and consequences of global warming are already evident. The increase of atmospheric concentrations of CO_2 and other greenhouse gases is well documented. There are many consequences such as increased mean temperature, which has led to a rapid retreat of alpine glaciers and the continental glaciers of Greenland and Antarctica, as well as reduction of pack ice in the northern hemisphere. **Sea level rises in two ways: increased water from glaciers and thermal expansion.** The melting of the great ice sheets continues to cause increased water in the oceans where it then undergoes thermal expansion. These two effects will purportedly cause sea level to rise several meters by 2100.

Climate shifts can affect **El Niño** and **La Niña** phenomena, which leads to drought or excessively rainy summer monsoon seasons. **Permafrost** is melting dramatically in the high arctic. Increased rain in the tropics causes **increased acidity in marine water** where it counteracts deposition of calcium carbonate in coral reef ecosystems. The complex rotation of oceanic currents which comprise the **ocean conveyor belt** depends on its density, which is affected by its salinity (dependent upon glacially derived melt water from Greenland and Antarctica) and temperature (determined by solar insolation and mean regional global

temperatures) may be disrupted as a consequence of global warming. This movement of vast amounts of ocean water by currents is responsible for heat distribution for our planet.

Reduction of climate change approaches vary in scope and complexity. Their long term benefits are debatable. A fundamental postulate is to **reduce greenhouse gas emissions,** namely CO_2. Since most carbon dioxide emissions are the result of combustion of fossil fuels, one way to reduce them is to improve efficiency. Also, moving away from internal combustion engines towards electric powered vehicles reduces emissions.

One way to reduce carbon dioxide emissions is by capturing the emission at its source. This is not feasible for vehicles but in might become more cost effective with advances in technology. Another method of **sequestering** carbon is by mass tree planting. Through the process of photosynthesis carbon dioxide is removed from the atmosphere and "fixed" in the form of carbon compounds such as lignin in woody plants where it is temporarily removed from the atmosphere.

The most important treaty regarding CO_2 emission limits was the **Kyoto Protocol** which was held in Kyoto, Japan during 1997. The purpose was to establish a timeline to cut carbon dioxide emissions produced by 160 nations. Developing countries argued that they should not be bound by the caps and eventual reduction because the problem was one which was rooted in emissions produced by industrialized nations. Industrialized nations viewed the parameters of the protocol as costly to markets and detrimental to industrial productivity. The industrialized nations also argued that if they were held to the protocol and the developing nations were not, no reduction in worldwide CO_2 would be realized and the industrialized nations would bear the cost of an ineffective program.

The United Nations Framework Convention for Climate Change (**UNFCCC**) resulted from the 1992 Earth Summit. While nations recognize CO_2 emissions are caused by mankind and they are detrimental to our climate nothing of substance has resulted from the UNFCCC.

GREENHOUSE EFFECT IMAGES
http://images.google.com/images?q=greenhouse+effect&um=1&ie=UTF-8&ei=-HmcSYrgLIG4twf1xtXZBA&sa=X&oi=image_result_group&resnum=4&ct=title

GREENHOUSE EFFECT/GASES/DISSENTING SCIENTISTS
http://environment.about.com/od/globalwarming/a/greenhouse.htm

THE EFFECTS AND CONSEQUENCES OF GLOBAL WARMING
http://www.buzzle.com/articles/effects-consequences-global-warming.html

NORTH ATLANTIC OSCILLATION
http://www.ldeo.columbia.edu/res/pi/NAO/

CARBON FOOTPRINT COUNTER
http://www.carboncounter.org/?gclid=CMmz5tSD55gCFQpinAodSxtNdA

CARBON FOOTPRINT REDUCTION AT WHAT COST?
http://www.coloradodaily.com/news/2008/jun/09/independent-ideas-global-warming-and-technology/

UNFCCC
http://unfccc.int/2860.php

KYOTO PROTOCOL
http://unfccc.int/kyoto_protocol/items/2830.php

MAUNA LOA OBSERVATORY
http://www.mlo.noaa.gov/

C. LOSS OF BIODIVERSITY

Intact ecosystems provide a cornerstone of our existence because they provide **ecosystem services**. Bacteria decompose our waste. Phytoplankton and terrestrial plants provide our oxygen. When we suffer loss of biodiversity, ecosystem services operate less effectively, which is detrimental to all life.

Habitat loss has resulted by mankind's ability to modify environments for our use coupled with the needs of an exponential population growth rate. Prime examples include the loss of wetlands, forests, grasslands, riparian areas and estuaries due to industrialization, urbanization and suburbanization. **Overuse, overharvest** and **overexploitation** are exemplified by the elimination of entire salmon fisheries because of the excessive harvests of reproducing adults' migration to their native stream tributaries. Cropland has also fallen victim to overuse because of repeated planting of the same crop year after year which depletes the soil of nutrients and leads to topsoil loss by erosion.

Pollution of water and air with chemical waste from industrial sources has rendered areas of the world so toxic that shellfish which grow there are unfit for consumption, if they are able to live there at all. The introduction of **non native species** into areas has led to the loss of native species because the non native species typically occupy a niche which lacks the natural predation typically found in their native environment and these introduced species out-compete native species. **Invasive species** also contribute (as do non native species) to **biotic pollution,** which is permanent. **Endangered and extinct species** serve as

barometers of our effects on the environment and particular biomes and ecosystems.

Of current notable scientific interest are the amphibians. Scientists view them as **indicator species** because they may serve as early warning barometers. They are in decline world wide and they exhibit genetic defects as well as disease and parasitism.

Humankind's history of domination of the natural environment has brought ecological disaster since we have congregated in "civilized" areas and left our nomadic ways behind, especially since the Industrial Revolution. Great advances in health care have enabled more of us (lower infant mortality) to live longer which has in turn required greater consumption of natural resources over time. Over the course of Earth's history there has always been **background extinction** which is the natural loss of species over time. This is to be contrasted against **mass extinctions** which occur catastrophically such as the end of the Cretaceous Period 65 million years ago, when the Yucatan Peninsula was struck by a large extraterrestrial body.

It is important to recognize the difference and value of **biodiversity, ecosystem diversity, species richness and genetic diversity.** These are arranged in order of decreasing broadness. For example, genetic diversity is the genetic variation within a species.

The value of diversity and richness is multifold. Intact ecosystems may offer scientific, pharmaceutical, industrial and agricultural solutions that may benefit mankind. Many examples can be cited, such as aspirin which is a derivative of the willow tree.

The concept of "maintenance through conservation" is a topic known as **Conservation Biology.** If a locality is selected for conservation biology such a portion of forest in Costa Rica this is "on site" or "**in situ"** conservation. Zoos are therefore and example of "off site" or **"ex situ"** conservation.

Relevant laws and treaties include:

Federal Noxious Weed Act
Wild Bird Conservation Act, 1992
Endangered Species Act, 1973
CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna)
World Conservation Strategy

BIODIVERSITY/GLOBAL ISSUES/LOSS/CLIMATE CHANGE
http://www.globalissues.org/issue/169/biodiversity

AMPHIBIAN LOSS DUE TO HABITAT LOSS
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B83WY-4RWPCJ5-2&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=88dfa56f0c3bc3da464c824439dca8d1

DISEASE, HABITAT LOSS, CLIMATE CHANGE LEADS TOAMPHIBIAN LOSS
http://www.guardian.co.uk/environment/2006/jul/07/endangeredspecies.biodiversity

INVASIVE ZEBRA MUSSELS IN THE GREAT LAKES
http://www.great-lakes.net/envt/flora-fauna/invasive/zebra.html#overview

MULTIPLE CHOICE

1. Ozone (O_3) in the stratosphere and troposphere

A. are mobile and cycle constantly
B. are both pollutants
C. are beneficial in both locations
D. are long lived molecules
E. none of the above

2. Ozone in the stratosphere

A. is depleted by CFC's
B. is depleted by halon
C. is not depleted by HCFC's
D. damages DNA
E. all of the above

3. Greenhouse gases

A. store solar energy on a molecular level
B. include CO_2, N_2O, CH_4, CFC's, water vapor and ground level O_3
C. absorb infrared radiation
D. have increased dramatically in atmospheric concentration since the beginning of the Industrial Revolution
E. all of the above

4. Countries arranged from least to greatest per capita CO_2 output are

A. China, India, Japan, Canada, United States
B. India, China, Canada, Japan, United States
C. Canada, Japan, India, China, United States
D. India, China, Japan, Canada, United States
E. None of the above

5. Current research has demonstrated that global climate change has affected all of the following except

A. amphibians
B. reefs
C. migratory birds
D. the amount of carbon on our planet
E. the rate and amount of photosynthesis on our planet

6. Ecosystem services are/provide

A. wilderness experiences for humans to enjoy a world free of mechanization
B. complex drainage patterns known as watersheds for fresh water
C. island communities of genetic reserves for future generations
D. can be problematic for snow gees in urban areas
E. necessary jobs under the Healthy Forests Initiative

7. Habitat fragmentation

A. is an accepted method of maintaining biodiversity within a threatened rural setting.
B. leads to small tracts of habitat with a high species richness
C. is useful as an in situ method of conservation biology
D. is an appropriate method of restoration ecology
E. was somewhat ameliorated by the creation of the Greater Yellowstone Ecosystem by incorporation of adjacent public lands

8. All of the following are examples of invasive fauna except

A. zebra mussels in the Great Lakes
B. tumbleweeds in the Americas
C. rabbits in Australia
D. the brown tree snake in Guam
E. camelids in Patagonia

9. Of the following human causes of species endangerment and extinction the most significant is

A. introduction of invasive species
B. habitat destruction/fragmentation
C. pollution
D. overexploitation
E. none of the above

10. A clear shortcoming of the Endangered Species Act is

A. that is has no provision for private property loss or compensation as the result of its implementation
B. that it does not provide the same and necessary protection as does the Marine Mammal Protection Act
C. that mammals and other vertebrate life forms receive more protection than invertebrates or flora
D. that once a species is placed on the endangered or threatened list it is never delisted
E. that the enforcement authority is the U.S. Fish and Wildlife Service

FREE RESPONSE

A graph of carbon dioxide (CO_2) concentration in our atmosphere (in ppm) verses time since the mid 1950's to 2005 can be constructed from data collected at the Mauna Loa Observatory (elevation 13697 feet, 4169 meters) in Hawaii. The trend is very linear after the early 1970's to 2005 and the values increase from about 315 ppm to 380 ppm during this 50 time span. Superimposed on this trend are annual maxima and minima which vary by about 5 ppm. Pre Industrial Revolution CO_2 concentration was about 290 ppm.

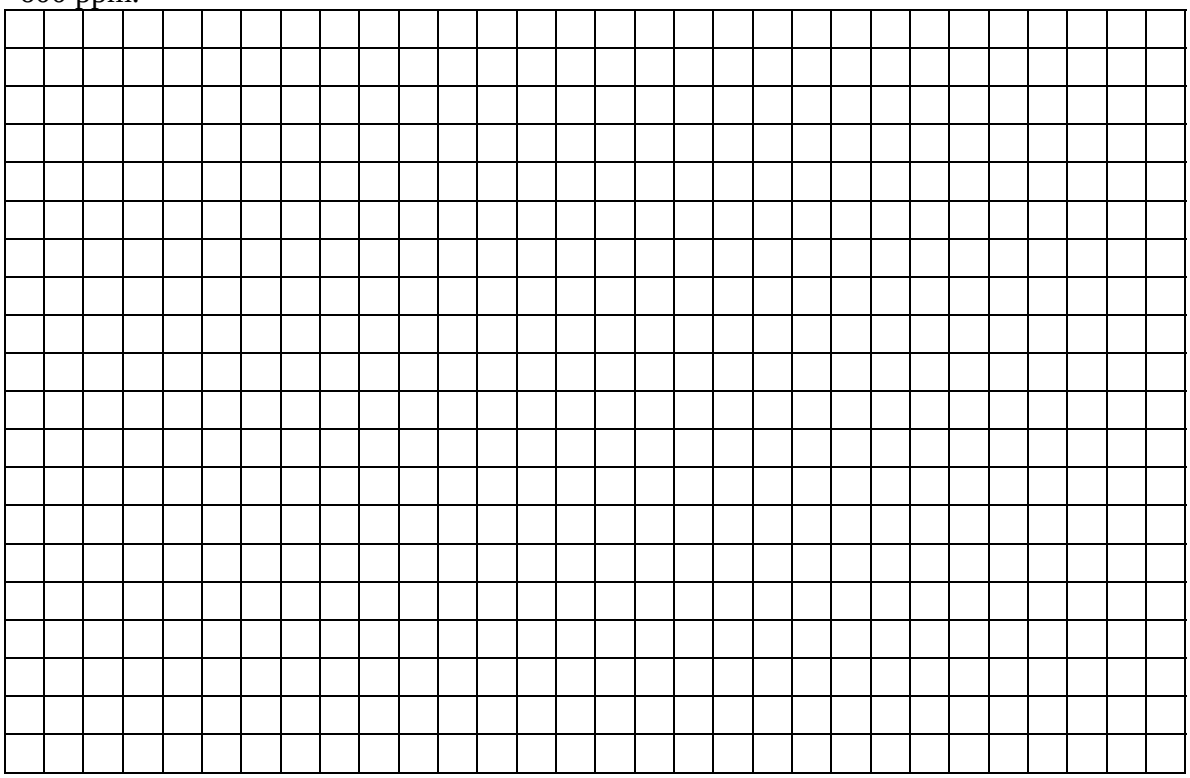
A. What is meant by "ppm"?

B. Describe why this location is a logical collection site.

C. How do we know the cited value of 290 ppm from 200 years ago?

D. Explain the 5 ppm annual spread between maxima and minima.

E. Construct a properly oriented graph of these data using the information above for the past 50 years but include extended scales for time to the year 2100 and concentration to 600 ppm.



F. Use your graph to predict an approximate date at which the CO_2 concentration will be approximately double that of the 1700's and place this point on you graph and clearly label it.

G. State the name and location of a notable volcanic eruption (other than the Hawaiian Islands), how and why global temperatures were affected and describe the duration of the effect.

H. Describe two interesting scientific facts about Mauna Loa other than any provided in this problem.