Student 2: High Merit

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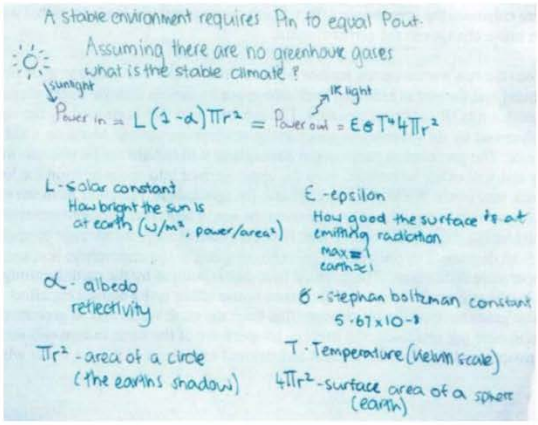
Note: The following is a snippet of the complete report that was written by the student.

To: Paula Bennett – The Climate Change Minister of New Zealand

After researching the physics behind climate change, I have come to a possible solution after investigating the advantages and disadvantages of the production of biochar. I have concluded that this is a very effective way of reducing Carbon Dioxide emissions into the atmosphere and will help decrease the rate at which the climate is changing.

The Physics behind a stable Climate Change: Power in = Power Out

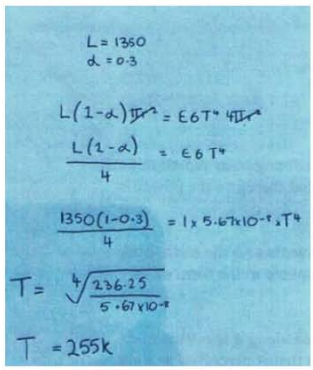
The energy requirements for a stable climate system is that the incoming solar radiation must balance the outgoing IR radiation emitted by the climate system and therefore the power in must equal the power out. The Earths energy system gains energy from sunlight which then warms up the earth, once the earth is warmed up it will emit energy back out into the atmosphere in the form of IR light. Electromagnetic radiation is classified by wavelength and stretched along a spectrum and separated into radio wave, microwave. infrared. the visible region that is perceived as light. ultraviolet. X-rays and gamma rays. The behavior of EM radiation depends on its wavelength.



1

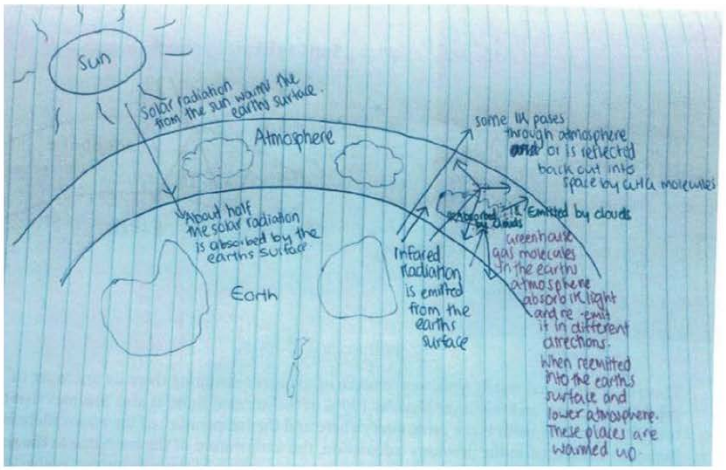
The predicted average stable temperature of the earth if it had no atmosphere

This is the calculation of the temperature of the earth assuming that there are no greenhouse gases. This is also assuming that the earth is not heating up and cooling down due to day and night and the constantly changing temperatures on earth. This calculation is also assuming the temperature across the earth is the same, however in reality it is not because as we know different countries around the world experience different temperatures and some places are warmer than others.
The temperature calculated without greenhouse gases was 255 Kelvins which is equivalent to -18.15 degrees Celsius. This is far too cold for organisms on earth to live so some greenhouse gases are good as they emit IR light back into the earth which makes the surface temperature of the earth warmer than what it would be without greenhouse gases. However, too much greenhouse gas is consequential.



2

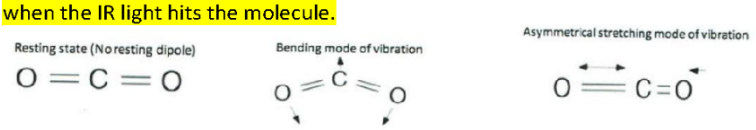
Energy from the sun warms up the surface of the earth. Half of this heat energy is absorbed by the ground and the rest is reflected back into space by clouds and the earth's surface. The warmed earth emits IR radiation upwards. The Infrared heat that is emitted by the earth is strongly absorbed by the greenhouse gases in the atmosphere such as Methane, C02 and water vapour. The greenhouse gases in the atmosphere will radiate the IR photons in different directions and will either be emitted from the upper surface into space or from the lower surface back into earth. Without an atmosphere, the upwards IR radiation from the earth would balance the incoming heart energy from the sun.



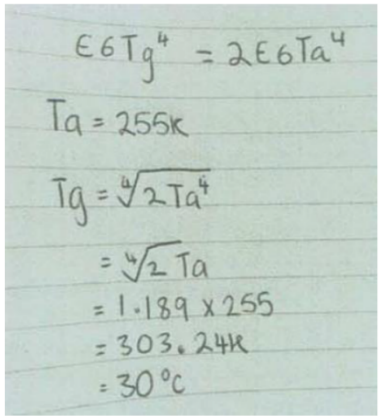
2

Common types of greenhouse gases include C02, Methane and Water vapour. Greenhouse gases vibrate at a particular frequency and have a natural frequency on the IR Spectrum, they vibrate due to the energy they absorb and can lose that energy by emitting it in the form of IR Radiation.

IR radiation has the same natural frequency of oscillation as the greenhouse gases and therefore the molecule will absorb the energy of the Infrared radiation. When the IR light hits the greenhouse gas molecule, it can create asymmetrical modes of vibration which shuffle the positive and negative charges around and therefore the IR light is absorbed. When the molecule stops vibrating and moving, this indicates that the IR photon has been emitted. C02 is symmetrical in its resting state, as is methane. However, there are modes of vibration that are capable of breaking this symmetry as atoms in these molecules have different electronegativity's which create bond dipoles and therefore allow for bending or stretching modes of vibration. H20 has 2 lone pairs of electrons and therefore has bond dipoles, this indicates an asymmetrical mode in which will be formed when the IR light hits the molecule. 4

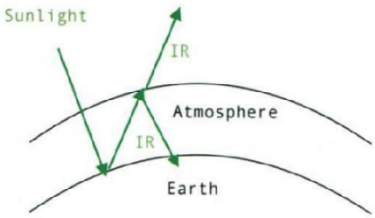


This is the predicted steady state temperature of the earth assuming there us one layer of greenhouse gases, and this layer absorbs l00% of the infrared light. It also assumes that the temperature of the earth is the same everywhere and the temperature of the atmosphere is the same. As calculated in the previous calculation, the temperature of the earth due to the solar constant is assumed to be 255k and therefore the temperature of the atmosphere is also 255k. The reason for the Epsilon x Stephan Boltzmann constant x Temperature of the atmosphere half of the equation being multiplied by two is because when the Infrared radiation gets absorbed by the greenhouse gases in the atmosphere, it can be emitted either back into the earth or out to space. However, this calculation is insufficient as we know that there isn't just one layer of Greenhouse gases. The atmosphere is obviously not l00% greenhouse gases, which means that there are gaps where the IR light will be able to pass through without being absorbed and can just travel straight out to space. The real atmosphere does not absorb all the IR light from the ground as the greenhouse gases are very selective.



3

The average temperature of the earth realistically is 15 degrees cooler than this predicted temperature. The steady state temperature of the earth can be predicted with a more sophisticated model http://climatemodels.uchicago.edu/rrtm/rrtm.doc.html.
This model predicts that if the earth has certain properties then it will lose as much energy as it gains (P in= P out). The model has default values whereby the steady state temperature is 284.42 K which is 11.27 degrees Celsius and the C02 concentration in the earth's atmosphere is set at 400 ppm. On the model, I doubled the C02 within in the atmosphere to 800ppm. According to the model, in order for the earth to lose as much energy as it gains with the C02 concentration of 800ppm, the steady state temperature would be 286.9k (13.75 degrees). This shows that as the C02 in the earth's atmosphere increases, so does the surface temperature of the earth.



There are feedback loops in the atmosphere that are either negative or positive and act as a stabilizer or amplifier, therefore the response will either push the temperature up or down to stabilise it or act in the same direction as the imbalance. The ice albedo feedback is a positive feedback to the earth's climate. The higher the albedo the colder the planet, and in this case when the light comes in a high majority of it gets reflected out to space and the sun light doesn't deposit its energy as heat to the planet, therefore will not heat it. Ice and snow is very reflective and therefore have a high albedo. A layer of snow over the ground will reflect visible light to space. Due to the increasing temperature of the earth, ice is melting and therefore there is less of it on earth, this means that there is less ice reflecting the visible light out to space and the planet is warming because the ground is absorbing more heat. The ocean has one of the lowest albedos on earth and therefore will absorb even more than the ground does. If we produce more C02, the ocean will absorb even more excess C02 to bring the C02 in the atmosphere back to equilibrium, therefore the ocean acts as a negative feedback response. 5
With the knowledge we have about Global warming, I think that people in today's society should start to take action to do things to set a more positive example for future generations to try and prevent climate change at such an alarming rate. If people in this world are able to consider ways of living that have a positive impact on the environment. by not only taking biochar techniques of riding agricultural wastes into consideration, but all of the many other solutions there are. Then it is possible that we can open our eyes and stop selfishly destructing this earth we were gifted with to live in.