HEAT **CO2 IR Absorption**

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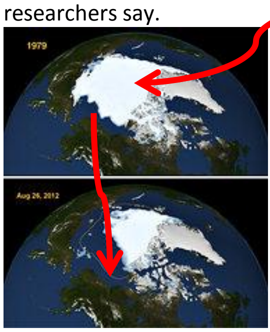
A Change in Temperature

Images from NASA show the extent **of ice covering the Arctic Ocean in 1979 and this month(2013), representing a decline of over 40 percent**, researchers say.



INTRODUCTION: The carbon dioxide and other gases in the atmosphere are virtually transparent to the visible radiation that delivers the sun's energy to the earth. ***But the earth in turn reradiates much of the energy in the invisible infrared region of the spectrum. This radiation is most intense at wavelengths very close to the principal absorption band (13 to 17 microns) of the carbon dioxide spectrum.*** When the *carbon dioxide concentration is sufficiently high(>300 ppm), even its weaker absorption bands(~ 4.26 mico meters) become effective, and a greater amount of infrared radiation is absorbed.*

QUESTION: Energy of *light* is expressed as the inverse of light wavelength($E \sim 1/\lambda$) since shorter the wavelength the more energy the light has($E = hf$, where f = frequency , h = planck's constant, and speed of light $c=\lambda f$, thus $f = c/\lambda$ and $E = hc/\lambda$, thus $E \sim 1/\lambda$). $1/\lambda$ = wave number. **(a) Show that if $1/\lambda = 2349\ cm^{-1}$, that $\lambda = 4.26 \times 10^{-6}$ m. (b) Show that if $667\ cm^{-1} = 1/\lambda$, that $\lambda = 15 \times 10^{-6}$ m . Note: 15 μm is main absorption λ.**

Since 1896, scientists have been trying to answer a deceptively simple question: **(((What will happen to the temperature of the earth if the amount of carbon dioxide in the atmosphere)))** The first to take a serious stab at it was **a Swede named (((Svante Arrhenius, in the late 19th century)))**. After laborious calculations, he declared that **(((if humans doubled the carbon dioxide in the air by burning fossil fuels))), the average temperature of the earth would rise by something like(((nine degrees Fahrenheit))), a whopping figure.** He was on the high side, as it turned out. In 1979, after two decades of meticulous measurements had made it clear that **the carbon dioxide level was indeed rising**, scientists used computers and a much deeper understanding of the climate to calculate a likely range of warming. They found that the response to a **doubling of carbon dioxide would not be much below three degrees Fahrenheit, nor was it likely to exceed eight degrees.** In the years since, scientists have been pushing and pulling within that range, trying to settle on a most likely value. Most of those who are expert in climatology subscribe to a **best-estimate figure of just over five degrees Fahrenheit.** What's new is that several recent papers have offered best estimates for climate sensitivity that are below four degrees Fahrenheit, rather than the previous best **estimate of just above five degrees**, and they have also suggested that the highest estimates are pretty implausible. Dr. Annan said in an e-mail that the Intergovernmental Panel on Climate Change(IPCC), a mainstream body that periodically summarizes climate science, should be bolder about ruling out extreme temperature scenarios, but he still believes global warming is a sufficient threat to warrant changes in carbon fuel use.

Carbon dioxide, a linear molecule, has 3 x 3 - 5 = 4 vibrations. **These vibrational modes, shown below left, are responsible for the "greenhouse" effect in which heat radiated from the earth is absorbed (trapped) by CO2 molecules in the atmosphere**. The arrows indicate the directions of motion. *Vibrations labeled A and B represent the stretching of the chemical bonds, one in a* ***symmetric (A) fashion, in which both C=O bonds lengthen and contract together (in-phase), and the other in an asymmetric (B) fashion, in which one bond shortens while the other lengthens.*** *The asymmetric stretch (B)* is infrared *active* because ***there is a change in the molecular dipole moment during this vibration***. To be "active" means that absorption of a photon to excite the vibration is *allowed* by the rules of quantum mechanics. [Aside: the infrared ***"selection rule" states that for a particular vibrational mode to be observed (active) in the infrared spectrum, the mode must involve a change in the dipole moment of the molecule.***] Infrared radiation at **(((2349 cm^{-1} (4.26 um) excites this particular vibration B)))**. The symmetric stretch is not infrared active, and so this vibration is not observed in the infrared spectrum of CO2. The two equal-energy bending vibrations in CO2 (C and D in Figure 4) are identical except that one bending mode is in the plane of the paper, and one is out of the plane. **(((Infrared radiation at 667 cm^{-1} (15.00 um) excites these vibrations))).**

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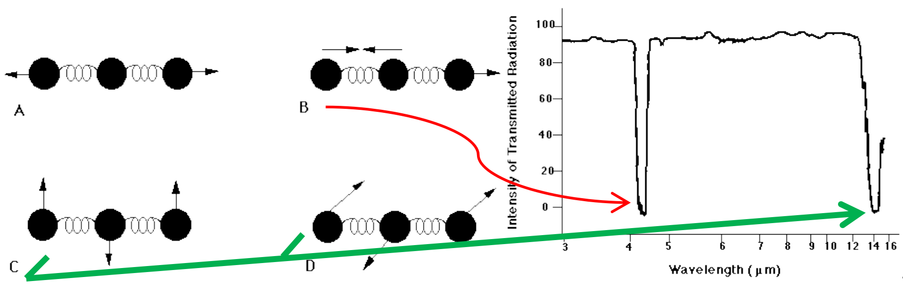

. Note that the intensity of the *transmitted* light is close to 100% everywhere *except* where the sample absorbs: at 2349 cm^{-1} (4.26 um) and at 667 cm^{-1} (15.00 um).