Physics 140

2/18/2019
• Molecular Bonds
• Molecular Vibrations
The Keeling plot charts

a) Global temperature vs. year.
b) Atmospheric methane concentration vs. year
c) Atmospheric carbon dioxide concentration vs. year
d) Global temperature vs atmospheric carbon dioxide concentration
e) Global temperature vs atmospheric methane concentration.
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b) Atmospheric methane concentration vs. year
c) Atmospheric carbon dioxide concentration vs. year
d) Global temperature vs atmospheric carbon dioxide concentration
e) Global temperature vs atmospheric methane concentration.
The term “climate forcing” refers to
a) the removal time of carbon dioxide from the Earth’s atmosphere
b) the temperature change caused by greenhouse gases
c) the introduction of sulfate aerosols into the Earth’s atmosphere to enhance cloud formation
d) the seeding of the oceans with minerals to encourage plankton growth to transfer carbon dioxide from the atmosphere to the ocean depths
e) the construction of a giant sunshade in space to reduce the Earth’s average temperature
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Greenhouse Gas

• A greenhouse gas allows energy from the sun (visible, ultraviolet) in.

• A greenhouse gas “scatters’ some of the outgoing radiation (infrared).
How Does The Greenhouse Effect Work

• The greenhouse effect is due to gases (greenhouse gases) that absorb radiation in the infrared but that are transparent to the visible part of the spectrum.
Recap

• Heat released from the Earth’s surface can be absorbed by certain atmospheric molecules.

• These molecules later release the heat in all directions, effectively trapping some of it.

• As a result of human activity the concentration of heat trapping gases in our atmosphere has increased.

• Burning of fossil fuels has increased concentration of $CO$ and $CO_2$

• Nitrogen oxides and methane result from agricultural and industrial processes.
Molecular Polar Bonds

• A bond dipole is a vector that represents the degree of charge separation in the bond.

• The sum of all bond dipole vectors in a molecule is the molecular dipole moment.
Molecular Vibrations

• Monoatomic gases (e.g. He) increase velocity as the temperature is increased.

• Polyatomic gases can vibrate as well as increase velocity when heat energy is added.

• When a molecule absorbs an amount of energy and vibrates, it has gone from its ground state to a vibrational excited state.
Vibrational States

• **Vibrational Energy Levels are Quantized.**
  • Only specific amounts of energy can be absorbed.

• Transitions between vibrational energy levels require much less energy than transitions between electronic energy levels.

\[ E = h \frac{c}{\lambda} \]

Electronic transitions \( \frac{1}{\lambda} \) is on the order of \( nm^{-1} \) while for vibrational transitions \( \frac{1}{\lambda} \) is in the order of \( cm^{-1} \).
\( \text{CO}_2 \) Vibrational Modes

• A \( \text{CO}_2 \) molecule has 4 vibrational modes, 2 stretching and 2 bending.

- Symmetric stretch \( 1500 \text{ cm}^{-1} \)
- Asymmetric stretch \( 2500 \text{ cm}^{-1} \)
- In plane bending \( 600 \text{ cm}^{-1} \)
- Out of plane bending \( 600 \text{ cm}^{-1} \)
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CO₂ Vibrational Modes

Vibrational modes in which the dipole moment is altered are heat absorbing. These are most important for climate
Greenhouse Gasses Contd.

$CO_2$

longer wavelength $\rightarrow$

$CO_2$ absorbs right at the peak of the blackbody spectrum of the earth!