# Chemistry C1404y (003) Spring Term, 2002

- FACULTY: Leonard Fine / Ann McDermott /Bhawani Venkataraman; and Luis Avila
- Webmaster: Michael Clayton
- Undergraduate Office:
  - Socky Lugo
  - Daisy Melendez

# Recitation Sections. Choose one!

- Monday 4:00 PM or Friday 2:00 PM
- **Teaching Assistant: Melissa Morlok**

# Syllabus for the Course

- Spectroscopy. Atmospheric gases
- Liquids and Solutions. Chapter 9
- Gas Phase Equilibria. Chapter 10
- Ionic Equilibria. Chapter 11
- Thermodynamics. Chapters 12/13
- Electrochemistry. Chapter 14
- Kinetics. Chapter 15

# ChemWrite

- Vaclav Smail: Enriching the Earth - Fritz Haber, Carl Bosch, and the Transformation of World Food
- Christian Warren: Brush with Death – A Social History of Lead Poisoning
- Linda Lear: Rachel Carson-Witness for Nature
- Kenneth Deffeyes: Hubbert's Peak-The Impending World Oil Shortage
- Mark Plotkin: Tales of the Shaman's Apprentice

# Translating CHEMWrite

Comment

Translation

- **You've got a solid, exploratory draft here, yet there are some points you might want to reconsider.**

# Translating CHEMWrite

| Comment | Translation |
| --- | --- |
| • **You've got a solid, exploratory draft here, yet there are some points you might want to reconsider.** | • Burn this and start over! |

# Translating CHEMWrite

Comment

Translation

- **I've never thought about it like that before.**

# Translating CHEMWrite

| Comment | Translation |
| --- | --- |
| • **I've never thought about it like that before.** | • That is the most absurd idea I've ever heard. Do you drink before class? |

# Translating CHEMWrite

| Comment | Translation |
| --- | --- |
| • I had some trouble understanding your concept. | |

# Translating CHEMWrite

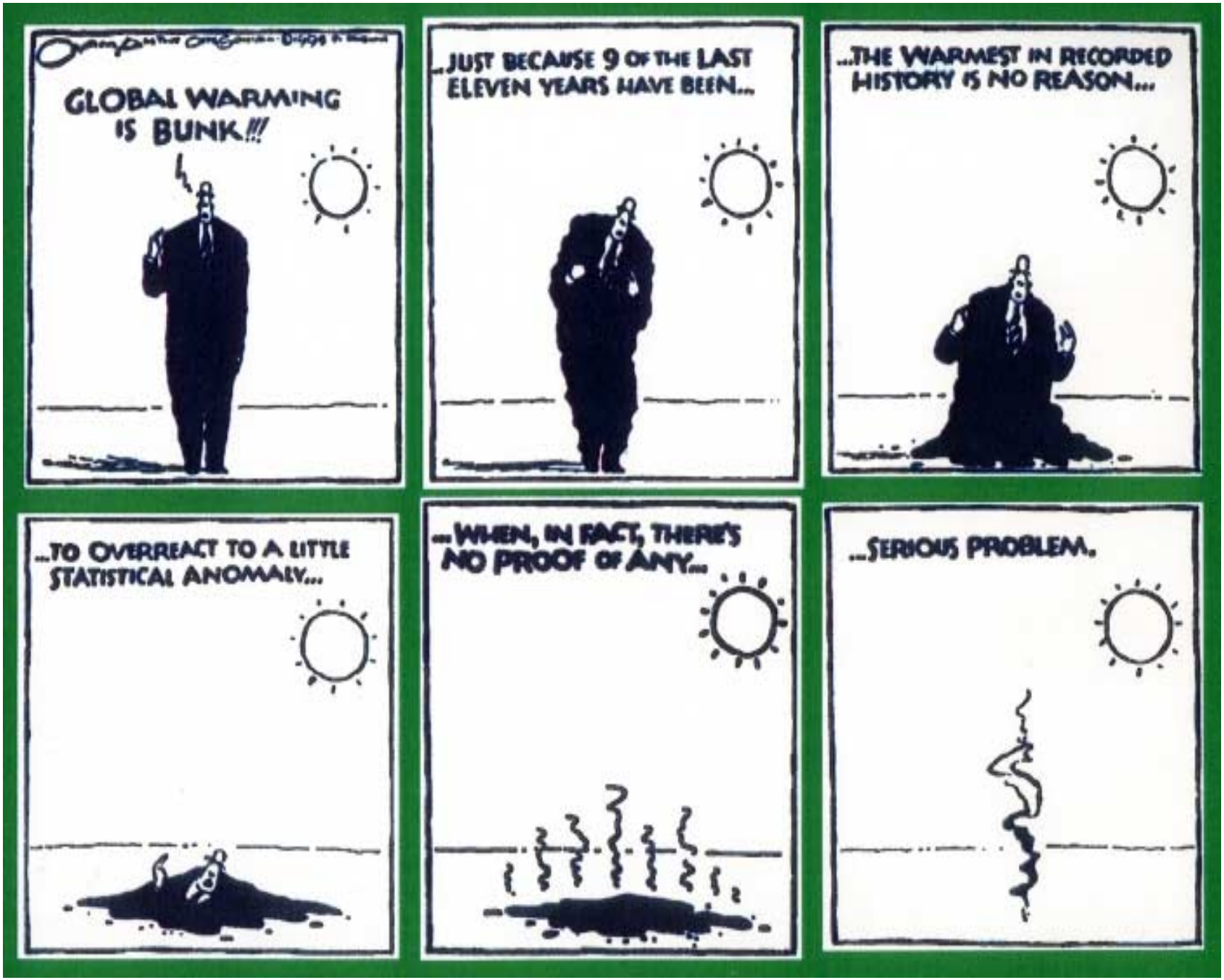
| Comment | Translation |
| --- | --- |
| • I had some trouble understanding your concept. | • I asked God to blind me while reading your paper. |

# Lectures/Exams

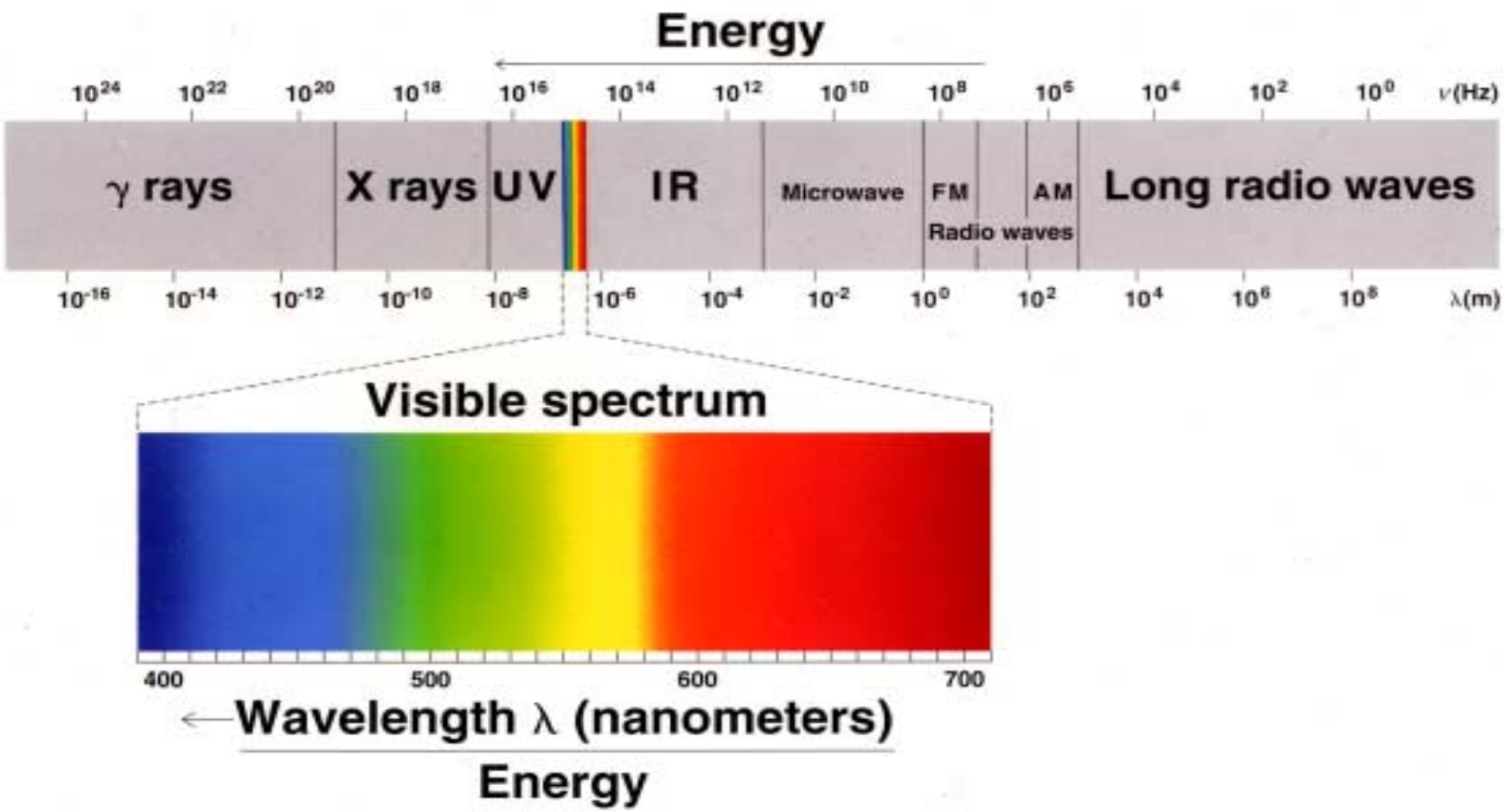
- Lectures: TR 1:10-2:25 (Section 003)
- Three 50-minute Exams (in class)
  - Highest to lowest:20%, 16%, and 12%
    - Tuesday 2/26,
    - Thursday 3/28
    - Tuesday 4/23
- Comprehensive Final Exam (28%)
    - Friday 5/10

# Lectures/Exams

- No make-up exams. No Kidding!
- WEB assignments (collectively) 8%
- ChemWrite 16%


GLOBAL WARMING IS BUNK!!!
..JUST BECAUSE 9 OF THE LAST ELEVEN YEARS HAVE BEEN...
...THE WARMEST IN RECORDED HISTORY IS NO REASON...
...TO OVERREACT TO A LITTLE STATISTICAL ANOMALY...
...WHEN, IN FACT, THERE'S NO PROOF OF ANY...
...SERIOUS PROBLEM.

# Electromagnetic Spectrum



# Spectroscopic Properties

$$Energy\ (E) = h\nu = h\frac{c}{\lambda} = hc\bar{\nu}$$

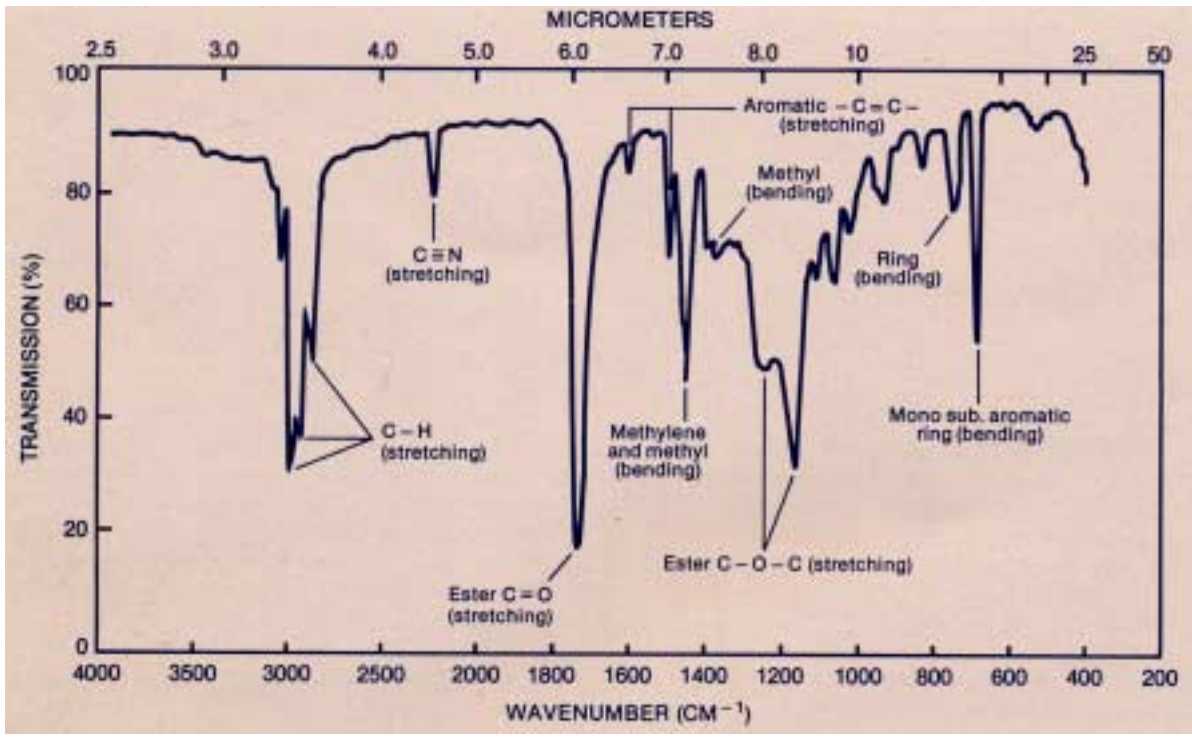
$$Frequency\ (\nu) = \frac{c}{\lambda}$$

$$Wavenumber\ (\bar{\nu}) = \frac{1}{\lambda}$$

# Spectroscopic Properties

- UV
  - 200 to 400 nm
- VIS
  - 400 to 800 nm
- IR
  - 2500 - 25,000 nm
  - 2.5 - 25 um
  - 4000 - 400 $cm^{-1}$

# Spectroscopic Properties




Infrared (IR) Spectroscopy is primarily used for qualitative and quantitative analysis of molecules in/as gases, liquids, solids, or solutions, based on the unique "fingerprint" provided by interaction with radiation in the range of 2.5-25 microns.

# Spectroscopic Properties

- Plot fraction of incident energy passing through a sample versus some measure of wavelength or frequency:

$$\frac{I(transmitted)}{I_0(incident)}$$

- Hooke's Law:

$$F = -kx$$

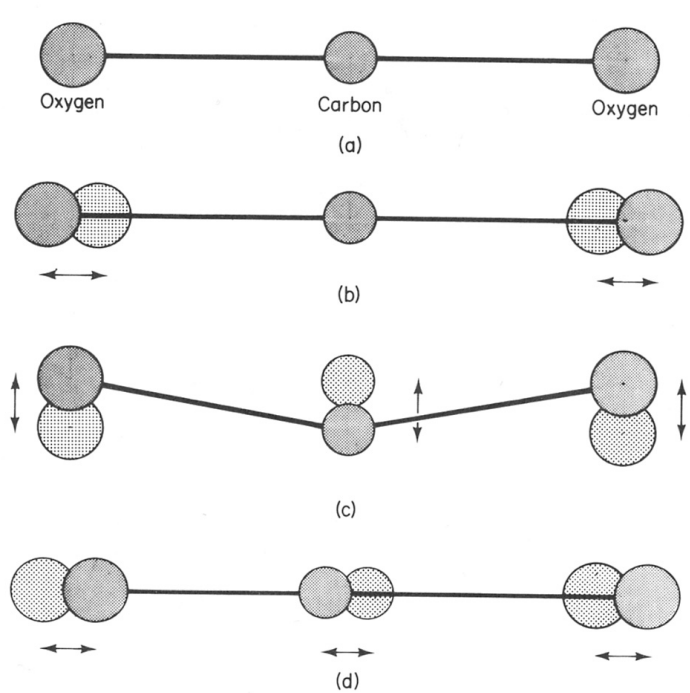
# Some Conclusions

- Frequency scales directly with bond strength (as measured by the force constant):
  - Triple bonds > double bonds > single bonds
  - 2150$cm^{-1}$ > 1650$cm^{-1}$ > 1200 $cm^{-1}$
- Frequency scales inversely with masses atoms:
  - The heavier the atom, the lower the frequency:
  - CO vs CS (1700$cm^{-1}$ vs 1350$cm^{-1}$)
  - CH vs CD (3000$cm^{-1}$ vs 2200$cm^{-1}$)

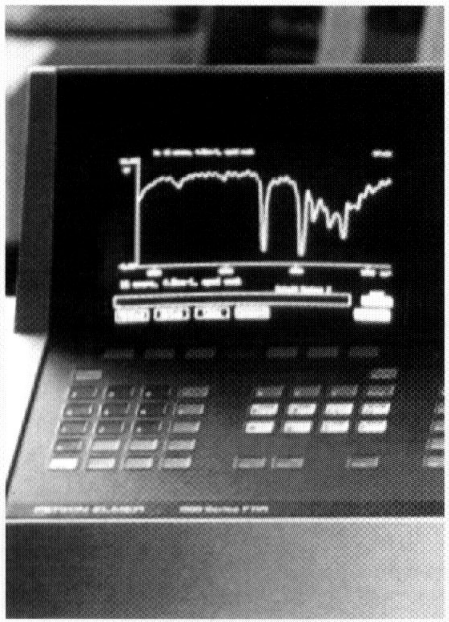
# Other Features

- Coupled frequencies: Antisymmetric stretching modes at higher frequencies (wave numbers) than symmetric stretching modes.
- Overtones: Excitations energies beyond first excited state.
- Bending, wagging, scissoring, rocking at typically at lower frequencies (than stretching modes).

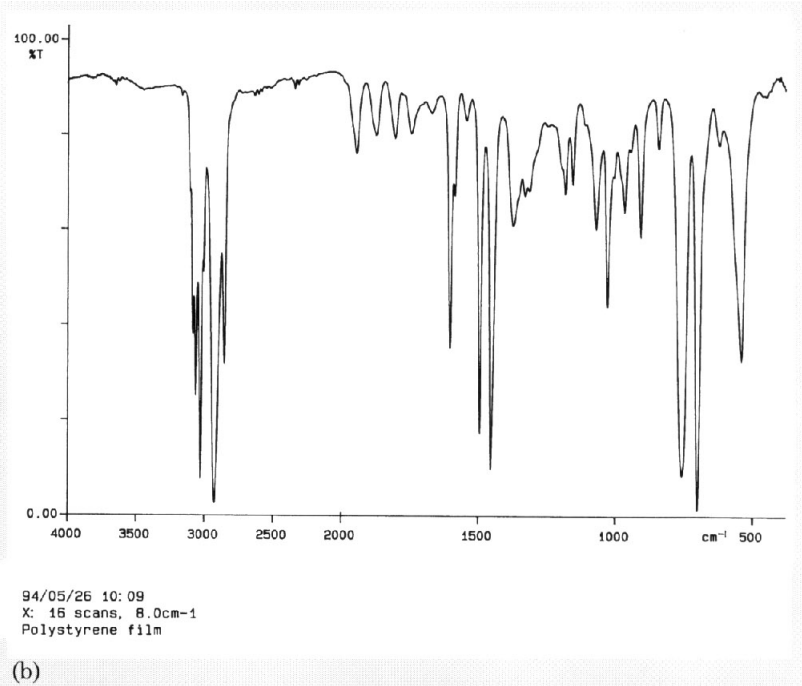
# CO2 Vibrational Modes



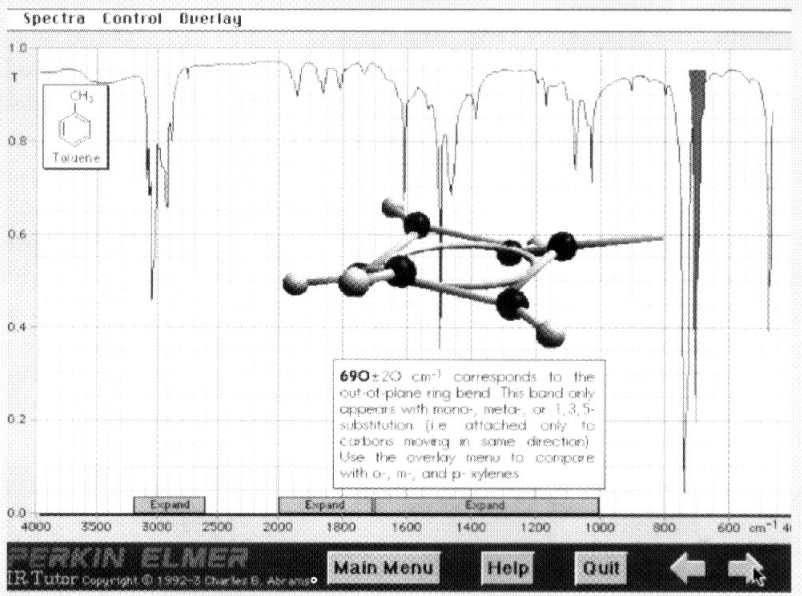
# IR spectroscopy



(a)

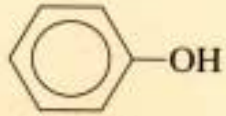
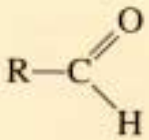
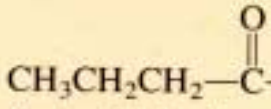
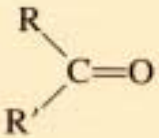
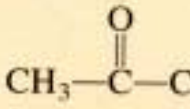
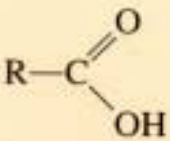
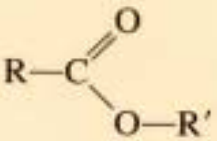
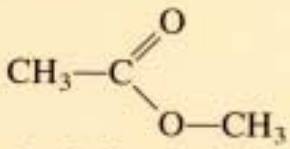
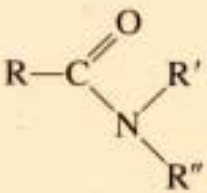
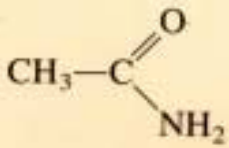



(b)



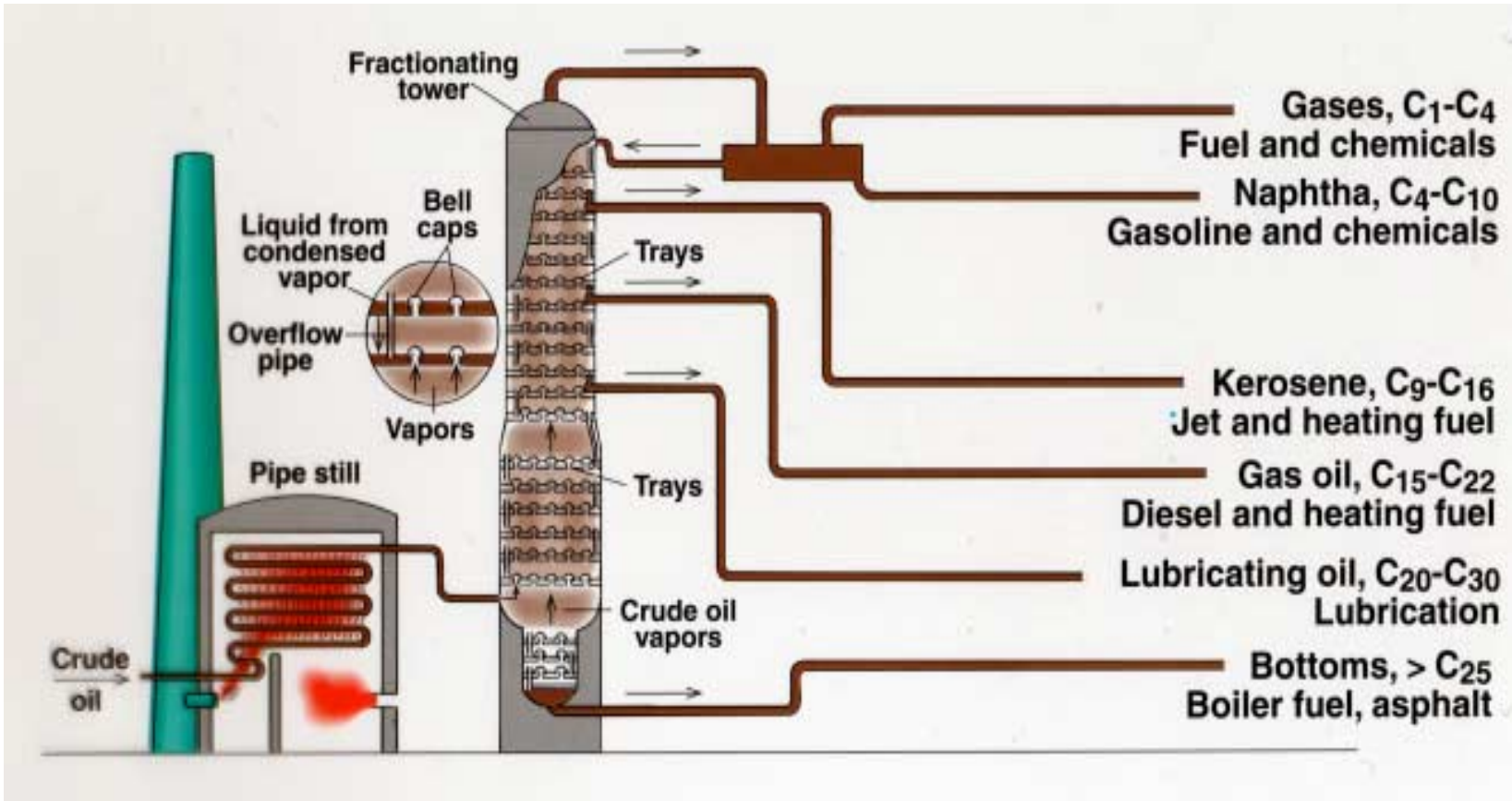

(c)

***Figure 6-6***
(a) A machine used to record the infrared sprectrum of a molecule. Shown here are the characteristic infrared sprectra of polystyrene (b) and toluene (c)

| Functional Group† | Type of Compound | Examples |
|---|---|---|
| R—F, —Cl, —Br, —I | Alkyl or aryl halide | $CH_3CH_2Br$ (bromoethane) |
| R—OH | Alcohol | $CH_3CH_2OH$ (ethanol) |
| | Phenol |  (phenol) |
| R—O—R′ | Ether | $CH_3—O—CH_3$ (dimethyl ether) |
|  | Aldehyde |  (butyraldehyde, or butanal) |
|  | Ketone |  (propanone, or acetone) |
|  | Carboxylic acid | $CH_3COOH$ (acetic acid, or ethanoic acid) |
|  | Ester |  (methyl acetate) |
| $R—NH_2$ | Amine | $CH_3NH_2$ (methylamine) |
|  | Amide |  (acetamide) |

# Pumping Oil

# Petroleum Distillation



# Natural Gases and gasolines

- Methane $CH_4$
- Ethane $CH_3CH_3$
- Propane $CH_3CH_2CH_3$
- Butane $CH_3CH_2CH_2CH_3$
- Pentane $CH_3CH_2CH_2CH_2CH_3$
- Hexane $CH_3CH_2CH_2CH_2CH_2CH_3$
- Heptane $CH_3CH_2CH_2CH_2CH_2CH_2CH3$
- Octane $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
  - n-octane 0-octane (straight-chain)
  - iso-octane 100-octane (highly branched)

**COMBUSTION is central to the consumption of most power.**

**Significant Exceptions:**

- **Nuclear**
- **Geothermal**
- **Solar.**

**Natural gas can be burned for home heating or electric lighting and the chemistry looks like this:**

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$$

**Direct conversion (home heating)**

**Indirect conversion, via steam to turbine electricity (lighting)**

**About 5-6 ounces of methane are required to provide enough heat for a comfortable bath for an average-sized adult in a tub appropriate in size for containing 20 gallons of water.**

**Do a Best Estimate/Good guess/Back-of-the-envelope approximate calculation to validate that assumption.**

# You will need to know….

- Specific heat
  - joules (or calories) per gram per degree
- Heats of combustion
  - Joules (or calories) per mole
- Conversion factors
  - Ounces of methane
  - Gallons of water

# $CO_2$ Crystals

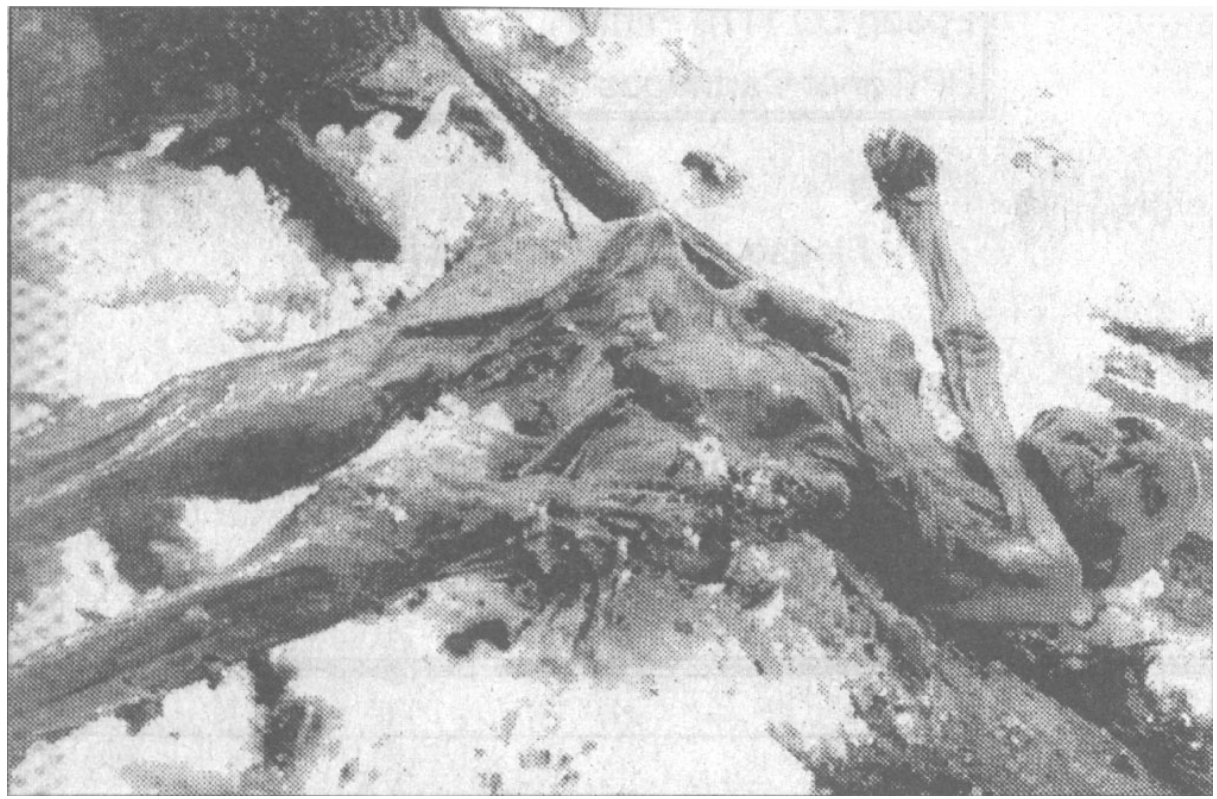
# Mount ETNA emits $CO_2$

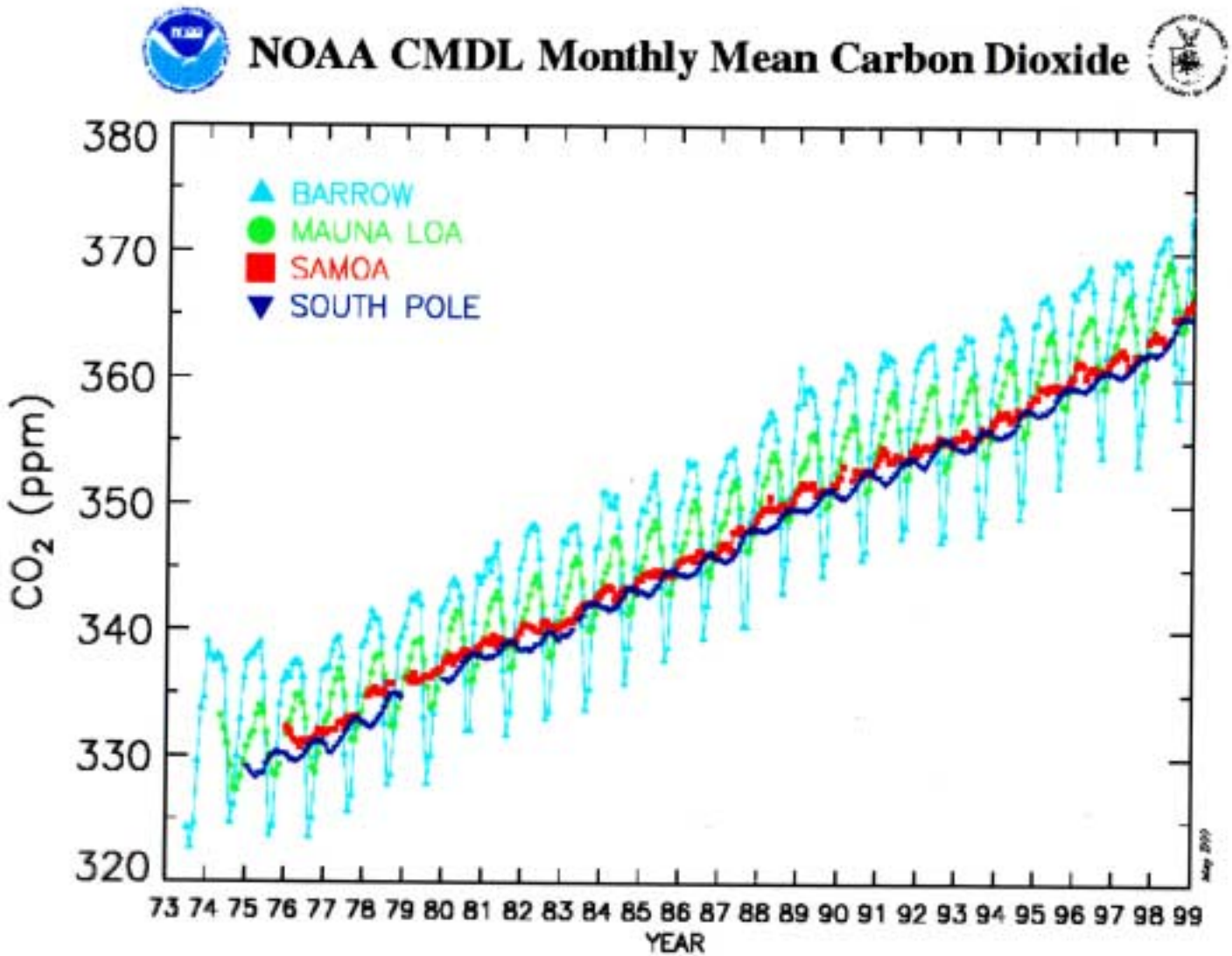
# Lake NYOS Eruption in the Cameroon

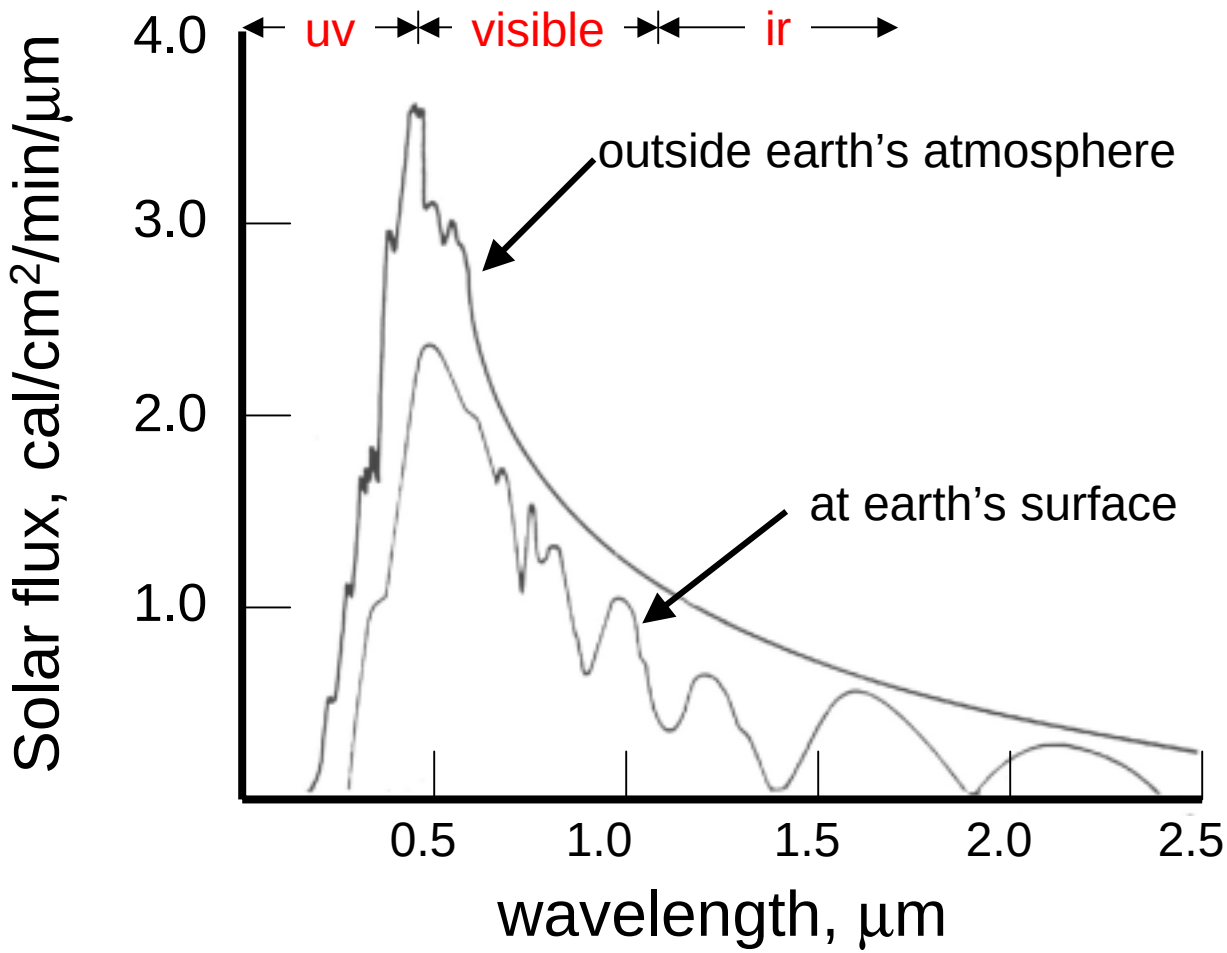
Iron deposits brought up from the bottom caused Lake Nyos to turn red after the gas explosion.

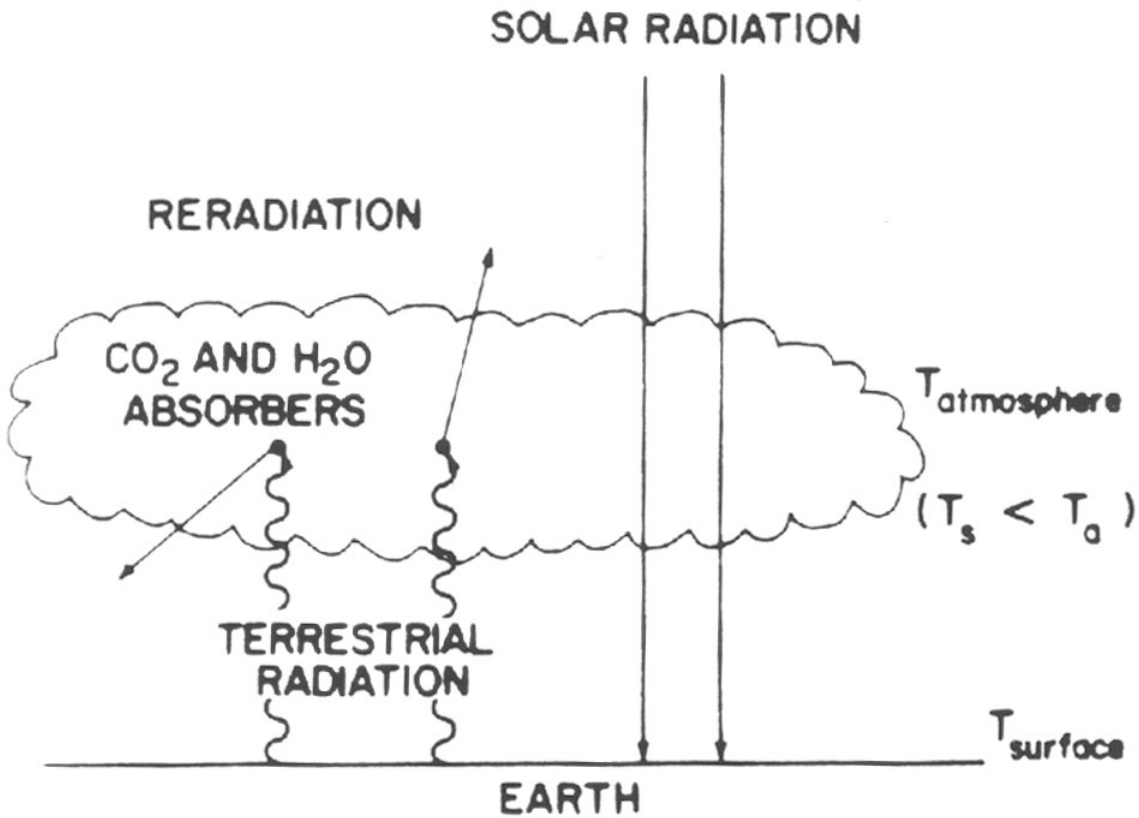
**Animation of lake explosion**

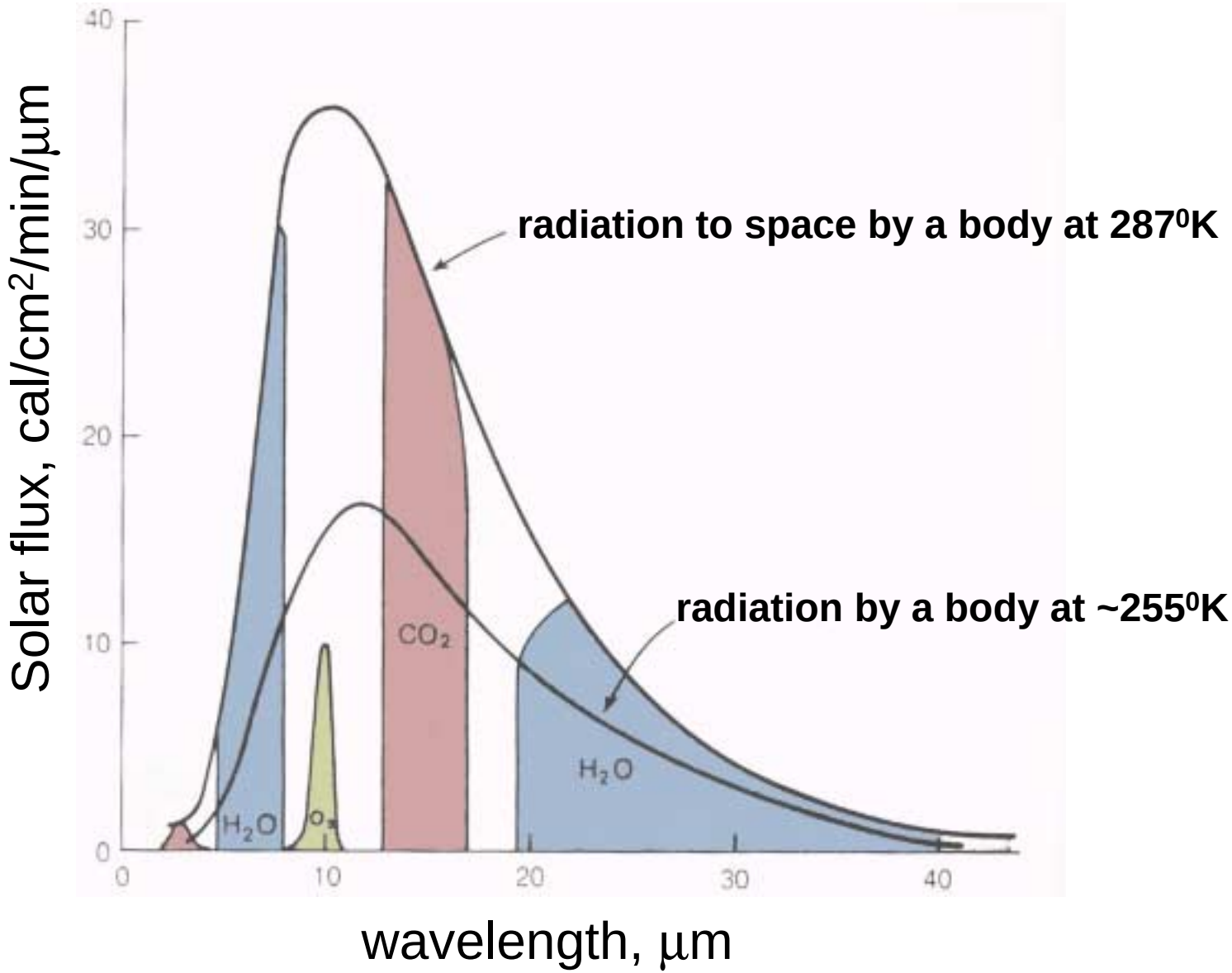
# ICEMAN

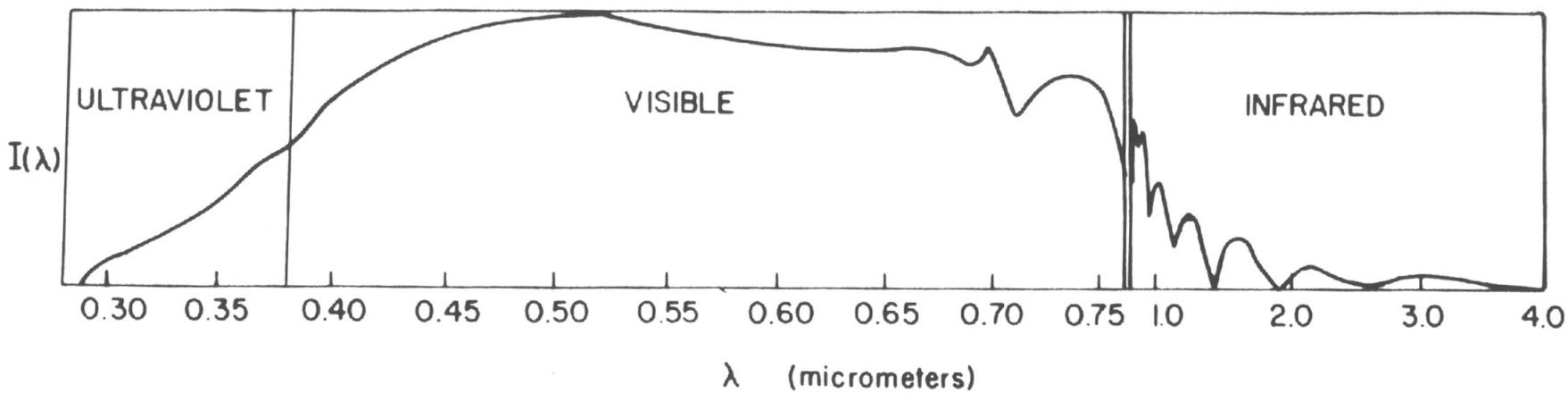


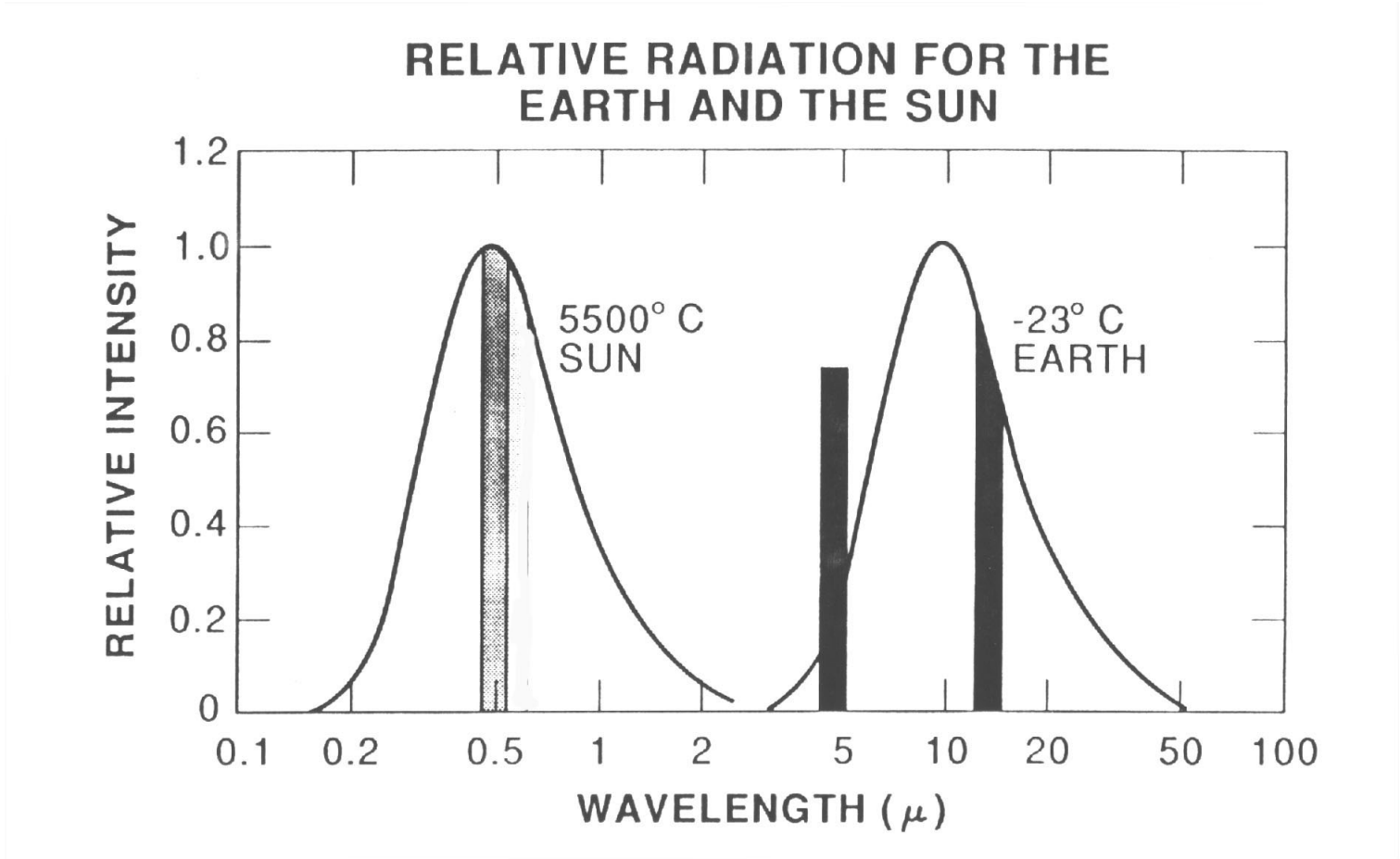

NOAA CMDL Monthly Mean Carbon Dioxide
BARROW
MAUNA LOA
SAMOA
SOUTH POLE
CO2 (ppm)
380
370
360
350
340
330
320
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99
YEAR

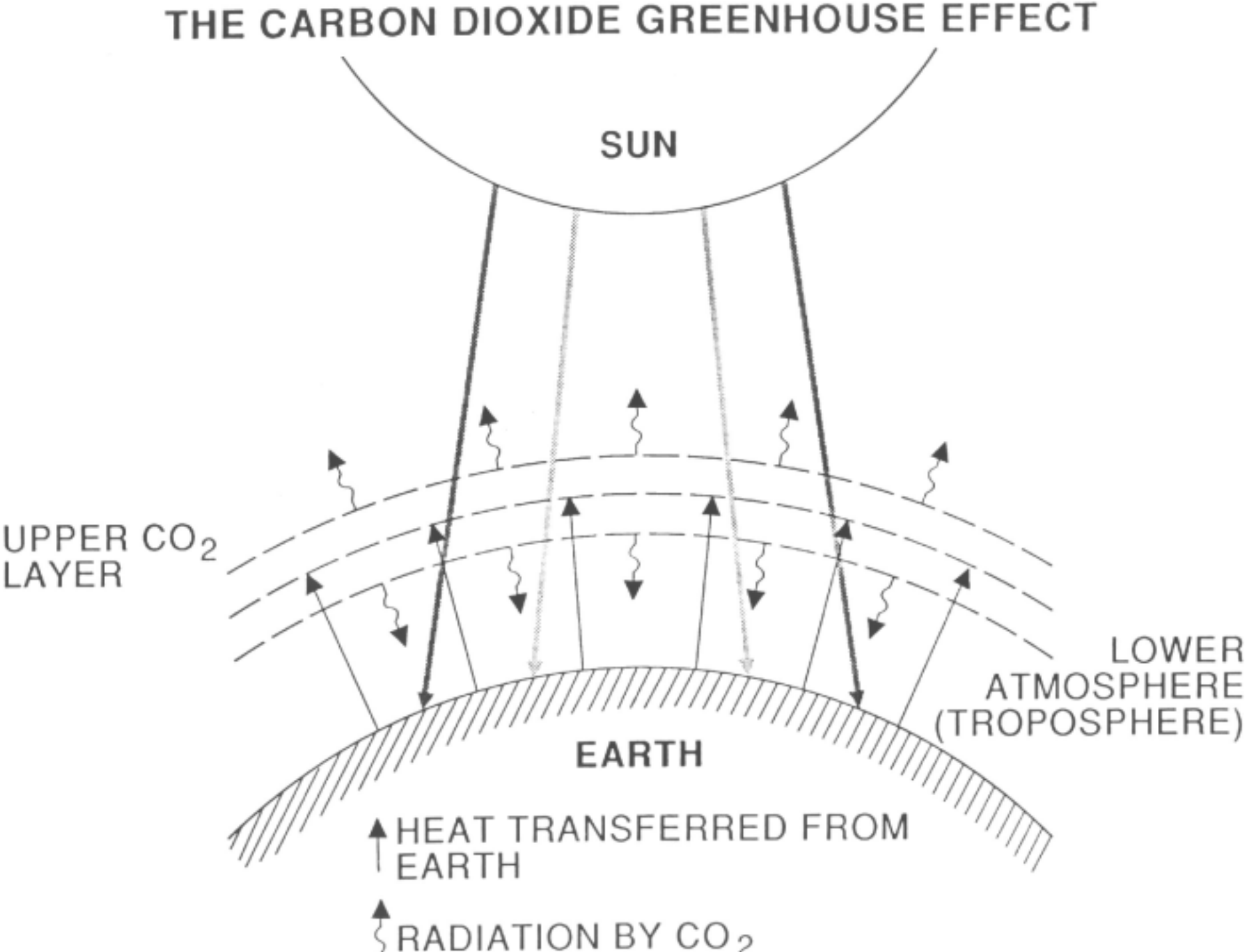

uv
visible
ir
4.0
3.0
2.0
1.0
Solar flux, cal/cm²/min/μm
outside earth's atmosphere
at earth's surface
0.5
1.0
1.5
2.0
2.5
wavelength, μm


SOLAR RADIATION
RERADIATION
$CO_2$ AND $H_2O$
ABSORBERS
$T_{atmosphere}$
($T_s < T_a$)
TERRESTRIAL
RADIATION
$T_{surface}$
EARTH

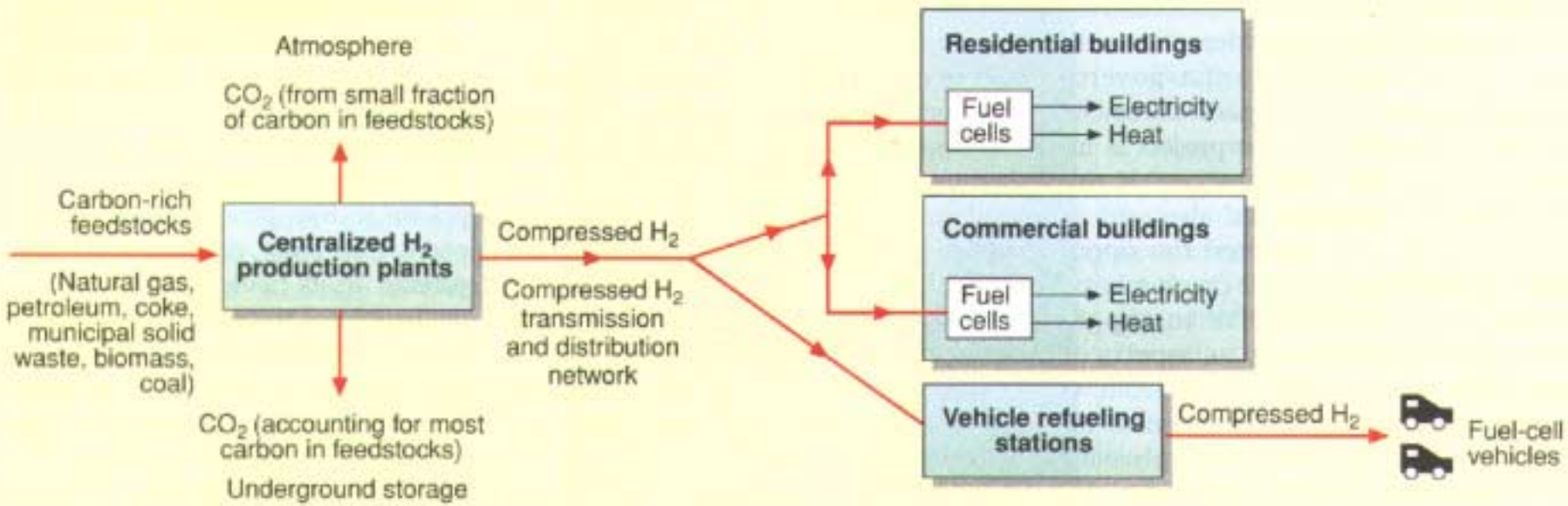

Solar flux, cal/cm²/min/μm
radiation to space by a body at 287⁰K
radiation by a body at ~255⁰K
CO₂
H₂O
H₂O
O₃
0
10
20
30
40
wavelength, μm


ULTRAVIOLET
VISIBLE
INFRARED
I(λ)
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
1.0
2.0
3.0
4.0
λ (micrometers)


RELATIVE RADIATION FOR THE EARTH AND THE SUN
RELATIVE INTENSITY
1.2
1.0
0.8
0.6
0.4
0.2
0
5500° C
SUN
-23° C
EARTH
0.1
0.2
0.5
1
2
5
10
20
50
100
WAVELENGTH (μ)


THE CARBON DIOXIDE GREENHOUSE EFFECT
SUN
UPPER $CO_2$ LAYER
LOWER ATMOSPHERE (TROPOSPHERE)
EARTH
HEAT TRANSFERRED FROM EARTH
RADIATION BY $CO_2$

## Hydrogen energy system would release little carbon dioxide to the atmosphere




Source: Robert H. Williams

# Chrysler Smart Car Hybrid Vehicle