The colors of flames of heated compounds are different from each other. These differences are an important clue about the structure of the atom.

Electromagnetic Radiation

- Light (electromagnetic radiation) obeys the physics of WAVES but also behaves as PARTICLES.
- See the properties of waves on CD-ROM screen 7.3.
  - Wavelength $\lambda$
  - Frequency $\nu$
  - Speed $c$
  - Amplitude
  - Node

For all waves, $c = \lambda \nu$.

For electromagnetic waves (i.e. light), $c = 3 \times 10^8$ m/sec in a vacuum.

Nodes in a standing wave are fixed in space (don’t move).
Electromagnetic Radiation

- Waves have a fixed frequency.
- We use the Greek letter “nu”, $\nu$, for frequency. The units are Hz (Hertz), which is 1/sec or “cycles per second”.
- $\lambda \cdot \nu = c$
  where $c =$ velocity of light $= 3.00 \times 10^8$ m/sec
- Long wavelength $\leftrightarrow$ low frequency
- Short wavelength $\leftrightarrow$ high frequency

Electromagnetic Radiation

Red light has $\lambda = 700$ nm. Calculate the frequency.

$$c = \lambda \nu \quad \text{or} \quad \nu = \frac{c}{\lambda}$$

$$700 \text{ nm } \cdot \frac{1 \times 10^{-9} \text{ m}}{1 \text{ nm}} = 7.00 \times 10^{-7} \text{ m}$$

Freq $= \frac{3.00 \times 10^8 \text{ m/s}}{7.00 \times 10^{-7} \text{ m}} = 4.29 \times 10^{14} \text{ sec}^{-1}$

Quantization of Energy

An object can gain or lose energy by absorbing or emitting radiant energy in QUANTA. The greater the energy of the radiation, the shorter its wavelength. See screen 7.5 on the CD-ROM.
The energy of a wave is proportional to its frequency:

\[ E = h \cdot \nu \]

where \( h = \text{Planck's constant} = 6.6262 \times 10^{-34} \text{ J} \cdot \text{s} \)

Light with large \( \lambda \) (small \( \nu \)) has a small \( E \). Light with a short \( \lambda \) (large \( \nu \)) has a large \( E \).

\[ \lambda = 700. \text{ nm} \]
\[ \nu = 4.29 \times 10^{14} \text{ sec}^{-1} \]

PROBLEM: Calculate the energy of 1.00 mol of photons of red light.

\[
E = (h \cdot \nu) = (6.63 \times 10^{-34} \text{ J} \cdot \text{s})(4.29 \times 10^{14} \text{ sec}^{-1}) = 2.85 \times 10^{-19} \text{ J per photon}
\]

\[ E \text{ per mol} = (2.85 \times 10^{-19} \text{ J/ph})(6.02 \times 10^{23} \text{ ph/mol}) = 171.6 \text{ kJ/mol} \]

This is in the range of energies that can break bonds.