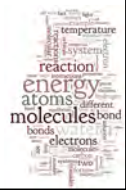
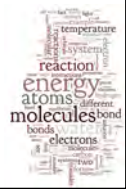
Light is a particle



So – light is a wave? With a frequency, a wavelength and speed?

Problem: wave nature of light does not explain some phenomena



Black-Body Radiation

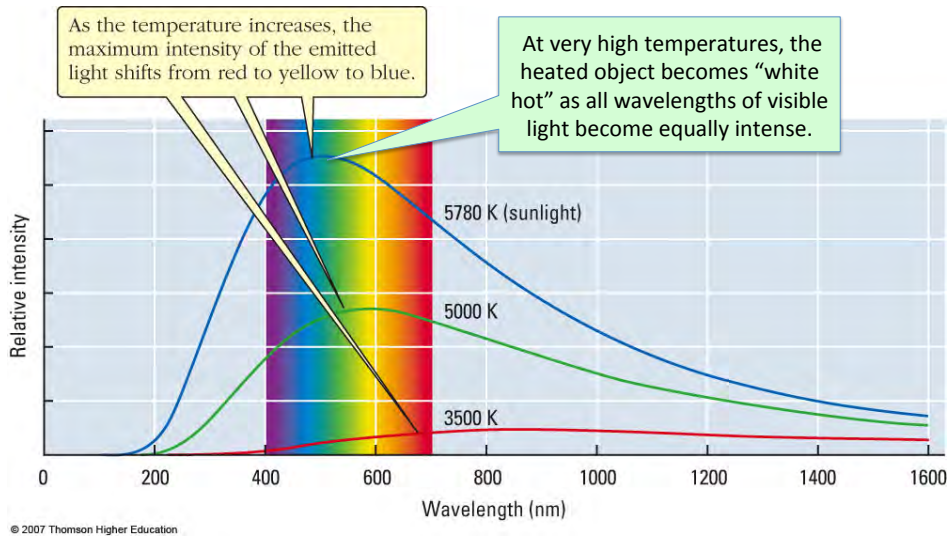
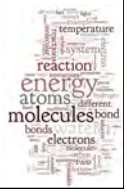


Fig. 7-3b, p. 276

Black-Body Radiation

- Matter emits radiation (energy) which changes in wavelength (and frequency) as the temperature increases.
- Warm blooded animals emit in the infra-red (night goggles see infra-red)
- As the temperature increases, the wavelength of light emitted does not correspond to "classical" wave theory



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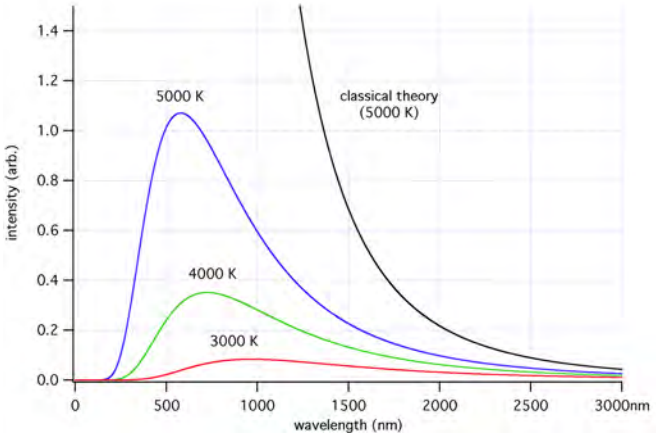
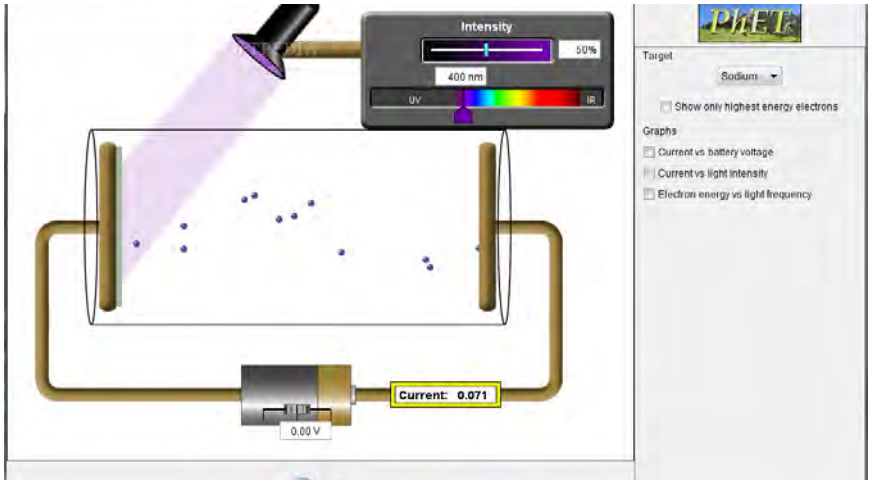
Ultra-violet Catastrophe



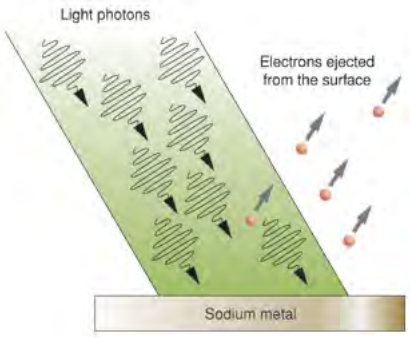
The photoelectric effect



Photoelectric Effect

- When light shines on a metal surface electrons are emitted – creating a current.
- The light is transferring energy to the metal surface – where it is transformed into kinetic energy that give the electrons enough energy to "leave" the atoms in the metal
- There is a threshold frequency below which no electrons are ejected – no matter how bright (intense) the light
- **If light were a wave** – increasing the intensity **should** increase the energy – and eject electrons

E/m radiation is a **particle** - Photoelectric effect

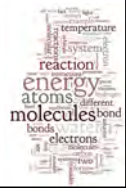


Photoelectric effect simulation

- Energy is transferred as a particle (photon) that has a definable energy.
- $E = h \nu$
- One photon ejects one electron
- If the photon does not have enough energy – then no electron is ejected

E/m radiation is a particle (and a wave)

- Planck $E = h \nu$ for the energy of a photon ($h = 6.626 \times 10^{-34}$ J.s)
  - E/m radiation comes as packets of energy - quantized
- Einstein - photoelectric effect - does not depend on the intensity - just the frequency (energy)



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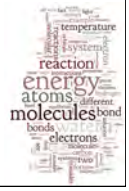
What is the energy of a photon of frequency $4.0 \times 10^{18} s^{-1}$
($h = 6.626 \times 10^{-34}$ J.s)

A. 2.6×10^{8} J
B. 2.6×10^{-15} J
C. 1.7×10^{-52} J
D. 6.0×10^{51} J



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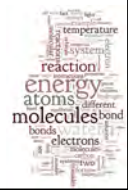
What is the wavelength of a photon of energy 6.2×10^{-8} J

A. 3.2×10^{-34} m
B. 3.2×10^{18} m
C. 3.2×10^{-18}m
D. 9.4×10^{25} m



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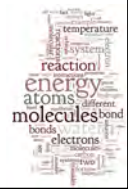
A hydrogen-hydrogen bond (in H_2) requires 7.2×10^{-19} J of energy to break the molecule apart.

What frequency of light does this correspond to?

What is the wavelength?

What consequences does this have in everyday life?

Ultraviolet radiation and radiation of shorter wavelengths can damage biological molecules because they carry enough energy to break bonds within the molecules. (visible is ~ 350 – 700)



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Electromagnetic Radiation

- Can be described as either a particle or a wave
- These are models – not reality!
- It is truly difficult to imagine these ideas – how can one phenomenon be two different things?
- Wave – particle duality is important at very small scales
- Matter and energy don't behave like they do in our macroscopic world

Where do those photons come from? **Why** is light different colors?