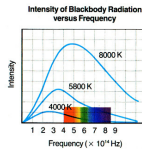


Planck's Quantum Hypothesis

- Hot objects emit light (red \Rightarrow yellow \Rightarrow white)
- Blackbody** - absorbs all radiation falling on it, so that any light observed is being emitted



- Electromagnetic wave theory predicted that objects would emit radiation, but did not accurately predict the observed spectrum of light at higher frequencies (**ultraviolet catastrophe**)
- In 1900, Max Planck suggested that the energy of vibration of the atoms in a solid is not continuous but can only have discrete values given by

$$E = nhf$$

- where **h** is Planck's Constant and has been found experimentally to be 6.626×10^{-34} Js

- Using these discrete energy values of hf , Planck was able to fit a mathematical equation to the **entire** blackbody curve.
- Revolutionary Idea: Energy exists only in discrete amounts!!!!**
- Smallest amount of energy possible (hf) is called a **quantum** of energy.
- Planck himself was not entirely happy with this idea, but this was in fact the birth of modern physics.

Photoelectric Effect

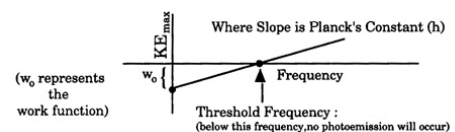
- Photoelectric Effect** - when light shines on a metal surface, electrons can be emitted from the surface. Only light above a certain frequency will cause this effect to happen;
- Wave theory does not accurately explain photoelectric effect.
- Einstein extended Planck's quantum theory to light in 1905 --- since all light ultimately comes from a radiating source, light may be transmitted as tiny packets (**photons**), each with an energy of hf

- Einstein's Photoelectric Theory**
 - one electron can be ejected upon collision with one photon, with the photon losing all of its energy
 - some minimum energy W_o (called the **work function**) is required to release the electron
 - if $hf > W_o$, the electron will be released. The maximum energy of the electron will be given by

$$KE_{\max} = hf - W_o$$

(for electrons buried deeper in the metal, more energy than W_o may be needed)

- Predictions** of Einstein's Theory
 - an increase in intensity means more photons hitting the metal, which should mean more electrons being released; the kinetic energy of each electron should not be changed
 - if $f < f_o$ (where f_o is the **threshold frequency** and $hf_o = W_o$), no electrons will be released
 - if f is increased, KE_{\max} increases linearly



- Einstein's predictions were verified by Millikan by 1916.
- Energy is often expressed in **electron volts** (eV). The electron volt is a smaller unit of energy than a joule

$$1 eV = 1.6 \times 10^{-19} \text{ J}$$
- The **Photoelectric Effect** provided the first evidence for a **particle theory of light**.

