The Radiation Laws, Atomic Structure, and Atomic Spectra

Blackbody radiation

[Diagram of blackbody radiation]

Blackbody curve

[Graph showing the blackbody curve with energy density vs. wavelength]
Total amount of energy a blackbody radiator emits and the energy it emits as a function of wavelength depends on its temperature.
The Radiation Laws – applies to EM radiation from any luminous or heated object

1. Any hot object emits energy at all wavelengths but not in equal amounts

2. Stefan-Boltzman Law

\[ L = 4\pi R^2 \sigma T^4 \]

Luminosity proportional to surface area \( \times \) \( T^4 \)

So a hot object emits more energy at all \( \lambda \) ‘s than a cooler one

3. Wavelength it emits most energy depends on temperature

\[ \lambda \text{ max} = \text{const} / T \]

Hotter -> shorter \( \lambda \) -> bluer

Cooler -> longer \( \lambda \) -> redder
Absorption and emission of radiation by an atom

\[ E = \frac{hc}{\lambda} \]

Atom was hit/bumped by another atom and gained some energy = \((E_2 - E_1)\). Electron in higher energy orbit \(E_2\).

Emission line produced!
Emissions of the Hydrogen Atom

The Balmer Series

Level 6→2
Violet

Level 5→2
Blue

Level 4→2
Green

Level 3→2
Red

Energy Absorbed

Energy Emitted
Each element has a different atomic structure and therefore a different spectrum.
Absorption line

Intensity

wavelength

photons from continuous source pass through thin gas

Cooler thin gas

Hotter continuous source

Zoom in on one gas atom

4 photons of different energy unaffected by atom, so all 4 make it to Earth

electron in lower energy orbit

photon of same Energy

Energy $E_2$

Energy $E_1$

One photon with Energy = $(E_2 - E_1)$ absorbed. Other photons continue on by.

Photon with Energy = $(E_2 - E_1)$ emitted in random direction. Instead of 4 photons, we only see 3 photons.
Kirchoff’s Laws

- Continuum Spectrum
- Emission Line Spectrum
- Absorption Line Spectrum