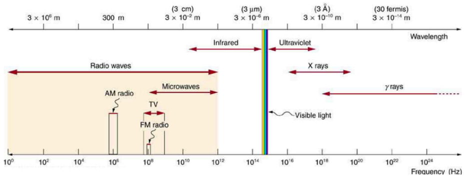
Introduction to Physical Science

Quantization & The Bohr Model

Presented by Robert Wagner

Electromagnetic Waves

- Travel at the speed of light:
  -
- Electromagnetic spectrum
  - Range of energies
- Blackbody radiation
  - Ideal emitter - emits radiation at all frequencies based on its temperature



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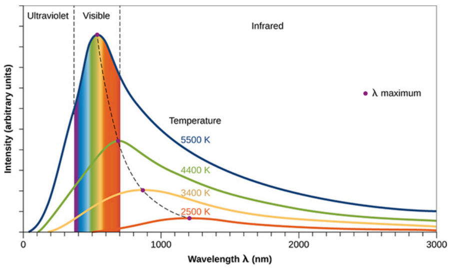


Photoelectric Effect

- Dual nature of light
- Acts as a particle or a wave depending on the circumstances
- Photoelectric effect - Einstein
  - Electrons are ejected only when photons of the minimum required energy strike the surface

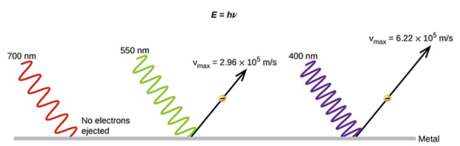


Figure 6.11 Photons with low frequencies do not have enough energy to cause electrons to be ejected via the photoelectric effect. For any frequency of light above the threshold frequency, the kinetic energy of an ejected electron will increase linearly with the energy of the incoming photon.

Example

- Light from a neon sign has radiation with a wavelength of 640 nm. What is the energy of the photon emitted?

$$\lambda = 640\, nm$$

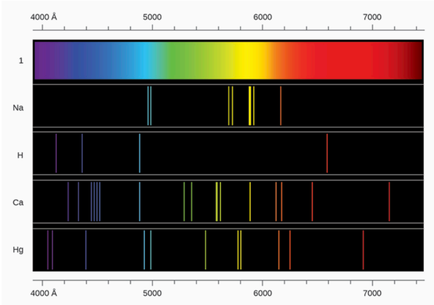
$$E = h\nu = \frac{hc}{\lambda}$$

$$E = \frac{(6.626x10^{-34}\, J \cdot s)(2.998x10^{8}\, m/s)}{(640\, nm)(\frac{1\, m}{10^{9}\, nm})}$$

$$E = 3.10x10^{-19}\, J$$

Line Spectra

- Energy only given off at specific wavelengths
- Pattern of lines is different for each specific type of atom
- Hydrogen - Balmer lines in visible spectrum. Followed a pattern based on whole integers



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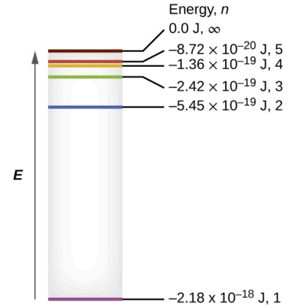
Bohr Model

- Previous examples - ideas of quantization
  - Theories that worked well in macroscopic domain did not work in the microscopic world of atoms
  - Specific discrete energy levels.
- Bohr model for single electron atoms



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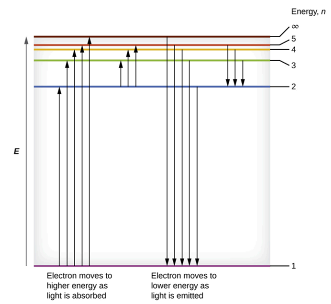

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Example

- If a spark promotes an electron in a hydrogen atom into an orbit with n=3, what is the energy in joules of the electron?

$$n = 3$$

$$E = -\frac{kZ^2}{n^2}$$

$$E = -\frac{(2.179x10^{-18}\,J)(1)^2}{(3)^2}$$

$$E = -\,2.421x10^{-19}\,J$$

Bohr Model - Summary

- The energies of electrons in an atom are quantized and described by quantum numbers.
  - Quantum numbers - integer numbers with specific allowed values
- An electron’s energy increases with increasing distance from the nucleus
- The discrete lines in the spectra of the elements result from the quantized energies of the electrons

Summary

- The photoelectric effect and the line spectra are examples that lead to the understanding of quantization
- The Bohr model explain the energy levels in a single electron atom
- Quantum numbers describe the specific states for electron energies