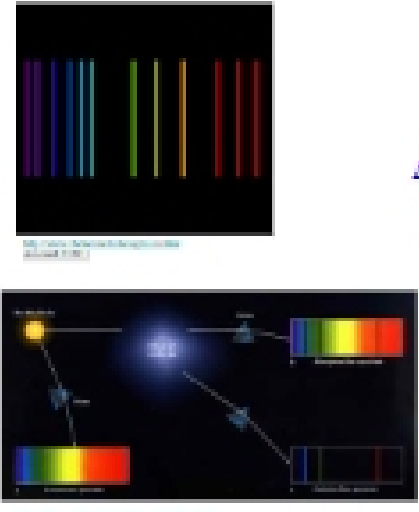


Chem 1315 Fall 2013

Dr. L. Clifford, Dept. of Chem. & Biochem., University of Oklahoma



CHEM 1315

Unit 4: Atomic Structure and Periodicity

Instructor:
Dr. Laura Clifford

Lecture notes
available at
<https://learn.ou.edu>

What formulas do I need to memorize?

For the next exam, you will need to commit the following formulas from Unit 4 to memory:

$v\lambda = c$

$E = h\nu$

$E = h \frac{c}{\lambda}$ (can derive this from previous two)

What information will I be given on the exam?

The following formulas and constants will be provided for you on the exam:

Planck's constant	$h = 6.6260755 \times 10^{-34} \text{ J}\cdot\text{s}$
Speed of light	$c = 3.00 \times 10^8 \text{ m/s}$
Rydberg constant (R_H)	$R = 1.097 \times 10^7 \text{ m}^{-1}$
$\Delta E = -hcR \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$	$\frac{1}{\lambda} = R \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

Quantum Mechanics

Quantum mechanics forms the foundation of chemistry:

- Explains the periodic table
- Explains the behavior of the elements in chemical bonding
- Provides the practical basis for lasers, computers, and countless other applications

Electron behavior determines much of the behavior of atoms.

Directly observing electrons in the atom is impossible; the electron is so small that observing it changes its behavior.

- Even shining a light on the electron would affect it.

Quantum Mechanics

The quantum-mechanical model explains the manner in which electrons exist and behave in atoms.

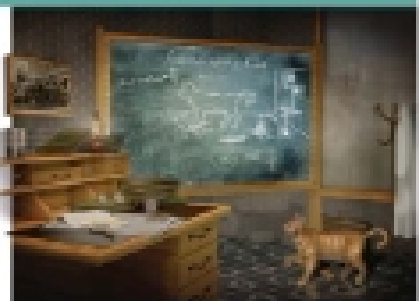
It also helps explain and predict the properties of atoms that are directly related to the behavior of the electrons:

- Why some elements are metals and others are nonmetals
- Why some elements gain one electron when forming an anion, whereas others gain two
- Why some elements are very reactive, while others are practically inert
- Why in other periodic patterns we see in the properties of the elements

Schrodinger's Cat

Quantum (small) versus macroscopic (large) view of the electron differs.

Although small, electrons influence the chemical and physical properties of an element.



The page 201, 202

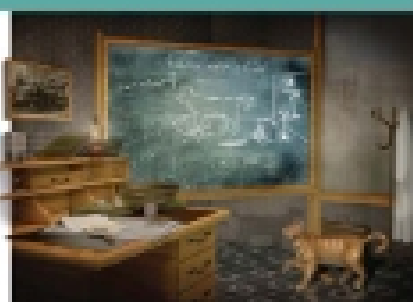
Schrodinger's cat: 1935 paper describing an experiment whereby a cat is placed into a steel chamber containing radioactive atoms. The chamber has a mechanism where a hammer will break a flask of hydrocyanic acid if energetic particles are produced by the radioactive atoms.

Schrodinger's Cat

While unobserved, the radioactive atom has both emitted the particle and not emitted the particle. The cat is both dead and alive.

Once the chamber is opened, observation forces the system into one state or the other (the cat is either dead or alive).

Schrodinger's experiment was meant to address the idea that quantum peculiarity does not translate to the macroscopic world.



The page 208, 2014

Learning Objective 4.1:

Relate color, λ , ν , speed, and energy of light being released or absorbed by atoms

Readings 7.1, 7.2

The wave nature of light

The present understanding of electronic structure of atoms comes from the understanding of visible light, one example of electromagnetic radiation.

Electromagnetic radiation: a form of energy that has wave characteristics and that propagates through a vacuum at the characteristic speed of 3.00×10^8 m/s.

- All electromagnetic radiation travels at the same speed, 3.0×10^8 m/s.
- Electromagnetic radiation has wavelike characteristics.



Figure 4.2, page 104, 2003

The wave nature of light

Energy is transmitted in the form of waves.

The distance between two adjacent peaks is called the wavelength, represented by the Greek letter lambda (λ).

The number of complete wavelengths (cycles) that pass a given point each second is the frequency, represented by the Greek letter nu (ν).

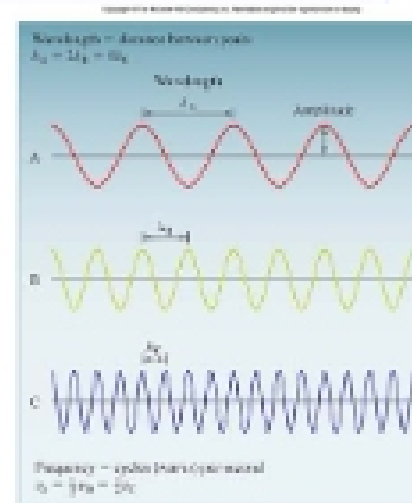


Figure 4.2, page 104, 2003

The wave nature of light

There is an inverse relationship between wavelength and frequency.

- The shorter the wavelength, the higher the frequency
- The longer the wavelength, the lower the frequency

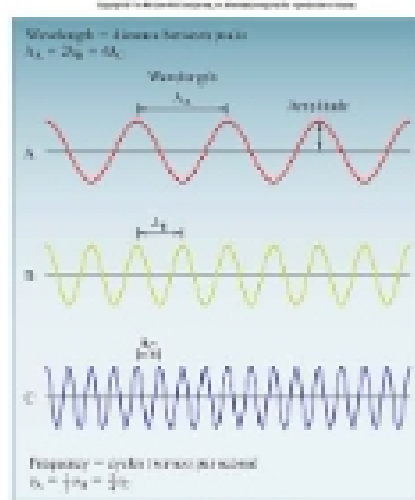
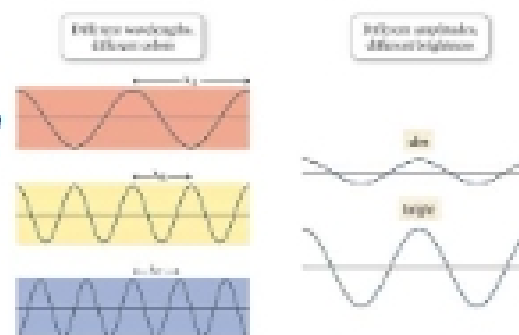


Figure 4.2, page 104, 2003

The wave nature of light

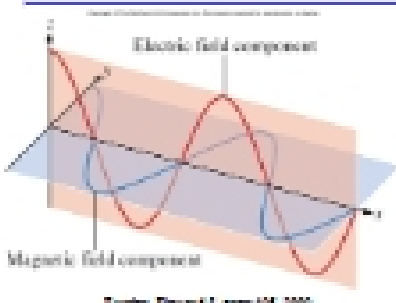
The amplitude of the wave (maximum extent of the oscillation of the wave) relates to the intensity of the radiation.

Waves may have the same frequency but different amplitudes.



The page 104, 2014

The wave nature of light



Electric field component
Magnetic field component

Source: Figure 6.1, page 104, 2000

Electromagnetic waves have two components that travel in perpendicular planes (have the same wavelength and same speed):

- Electric field component
- Magnetic field component

Why is this model important?

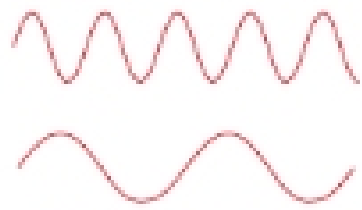
- Provides mathematical basis by which to explain the behavior of light.

The wave nature of light

The inverse relationship between wavelength and frequency is expressed by

$$v\lambda = c$$

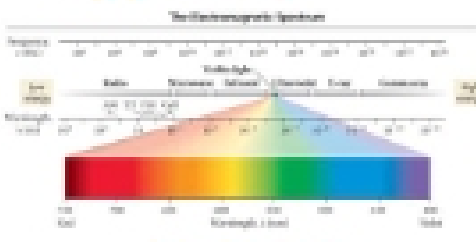
v = frequency λ = wavelength c = speed of light



Source: LeMay, and Bursten, page 220, 2004

The wave nature of light

Electromagnetic radiation forms have different properties due to the various wavelengths. Wavelengths range from very small (gamma rays) to very large (radio waves).



The Figure 7.6, page 200, 2011

Frequency is expressed in cycles per second (reciprocal seconds), /s or s⁻¹.

This unit is also called the hertz (Hz).

The wave nature of light

Example: A laser used in eye surgery to fuse detached retinas produces radiation with a wavelength of 640.0 nm. Calculate the frequency of this radiation.

Using: $v\lambda = c$

$v = ?$ $\lambda = 640.0 \text{ nm}$ $c = 3.00 \times 10^8 \text{ m/s}$

Note units: wavelength is often given in units of nm.

$$1 \times 10^9 \text{ nm} = 1 \text{ m}$$

The wave nature of light

A laser used in eye surgery to fuse detached retinas produces radiation with a wavelength of 640.0 nm. Calculate the frequency of this radiation.

Convert 640.0 nm to m:

$$640.0 \text{ nm} \times \frac{1 \text{ m}}{1 \times 10^9 \text{ nm}} = 6.400 \times 10^{-7} \text{ m}$$

$v\lambda = c$

$v = ?$ $\lambda = 6.400 \times 10^{-7} \text{ m}$ $c = 3.00 \times 10^8 \text{ m/s}$

$$v = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{6.400 \times 10^{-7} \text{ m}} = 4.688 \times 10^{14} \text{ s}^{-1}$$

The wave nature of light

An FM radio station broadcasts electromagnetic radiation at a frequency of 103.4 MHz. Calculate the wavelength of this radiation.