EXPERIMENT 5

ATOMIC, MOLECULAR, AND MASS SPECTRA

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Part 1

Atomic Emission Spectra

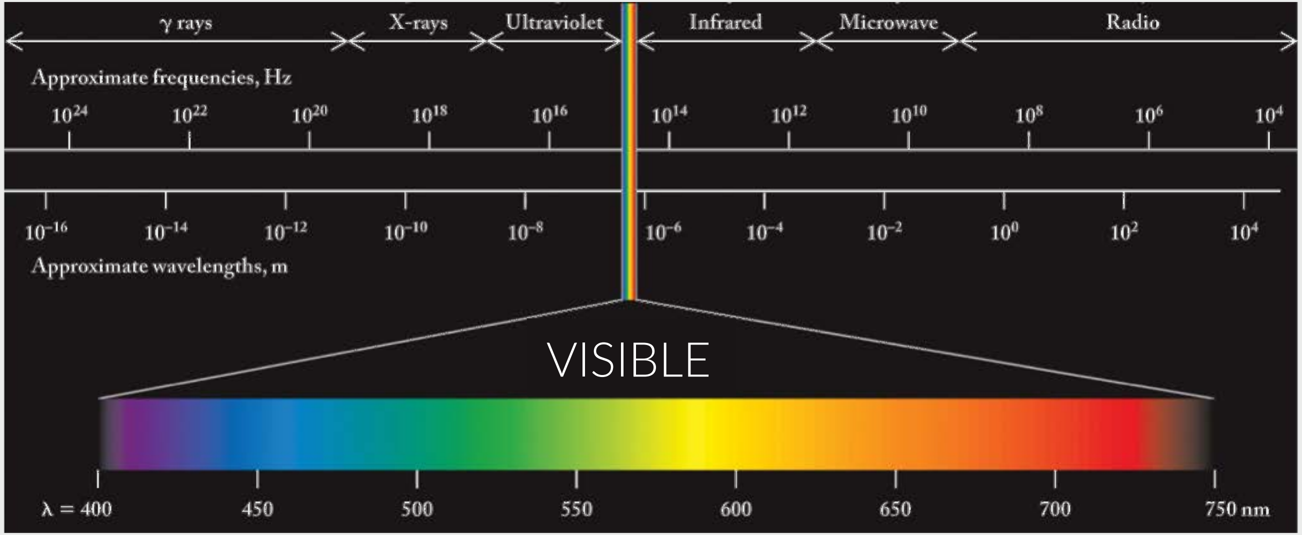
$$c = \lambda \times \nu$$

speed of light (m·s⁻¹)

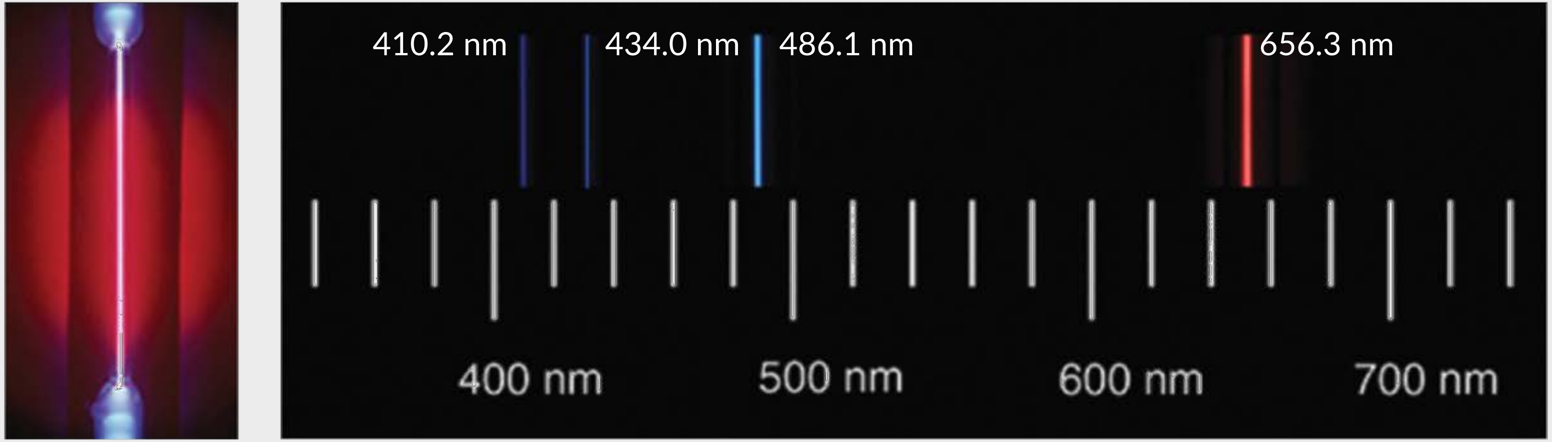
wavelength (m)

frequency (s⁻¹)

Electromagnetic spectrum



Line spectra of gases & atoms

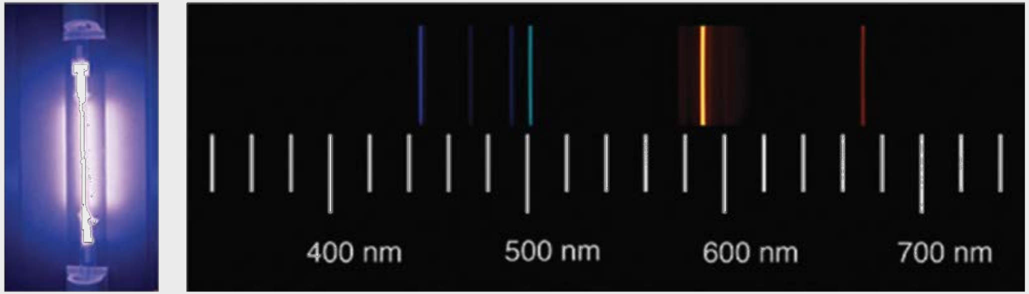


Hydrogen

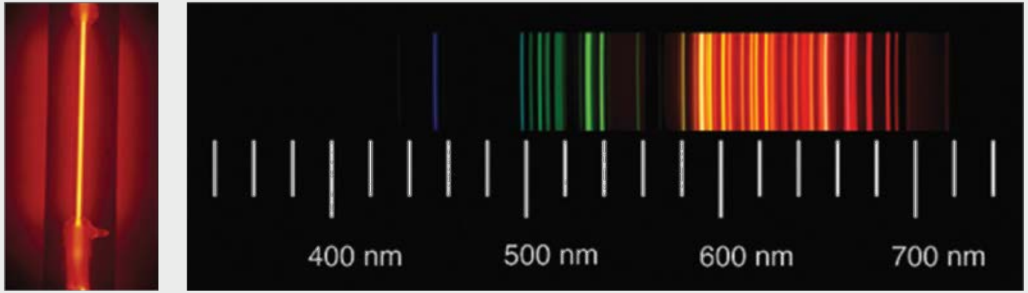
When we look at a hydrogen discharge lamp through a prism or a diffraction grating, we find that only <u>specific wavelengths</u> are emitted, and many more missing—for example, there is no orange or yellow.

This is true of all elements in the gaseous/vapor phase. Each element has its characteristic emission spectrum.

Helium



Neon



Rydberg Equation

Nearly a century ago, Balmer observed these specific "visible" colors, experimentally measured their wavelengths, and showed they obeyed the equation below with:

- $n_2 = 2$
- $n_1 = 3$ (red), 4 (green), 5 (blue), 6 (violet)

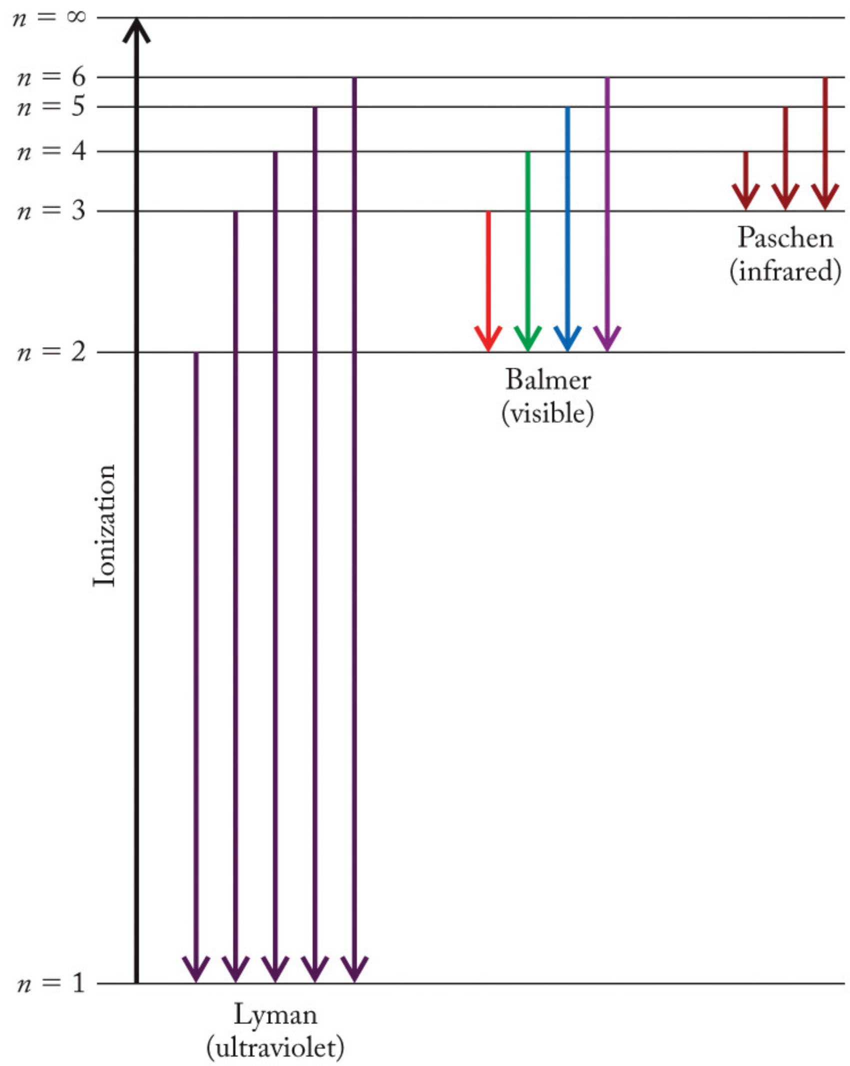
Rydberg later showed that other wavelengths (even those in the UV and IR region) emitted by hydrogen obeyed the equation as well with:

- $n_2 = 1$ or $n_2 < n_1$
- $n_1 = 2, 3, 4, 5, 6$, etc.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$$

R is the Rydberg constant (of nature).

You will determine R today!

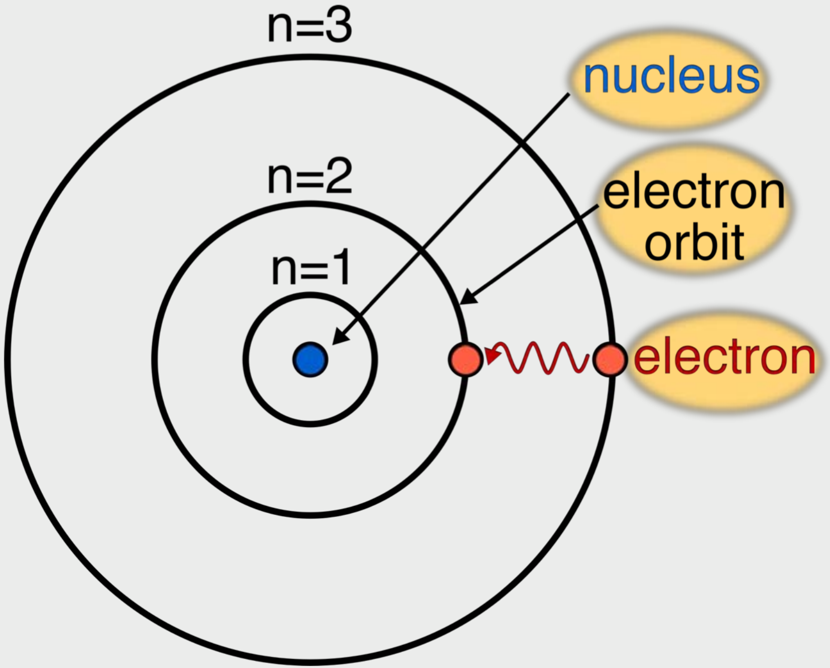


Bohr's Theory of the Hydrogen Atom

Neils Bohr visualized the electron in a hydrogen atom in terms of "solar system," and theorized that the electron has many energy levels.

Applying some physics (angular momentum) to his picture of electrons in orbits, he was able to derive his equation for the energy (E_n) of the electron as a function of its energy level (n).

$$E_n = -\frac{R_{\mathrm{H}}}{n^2}$$



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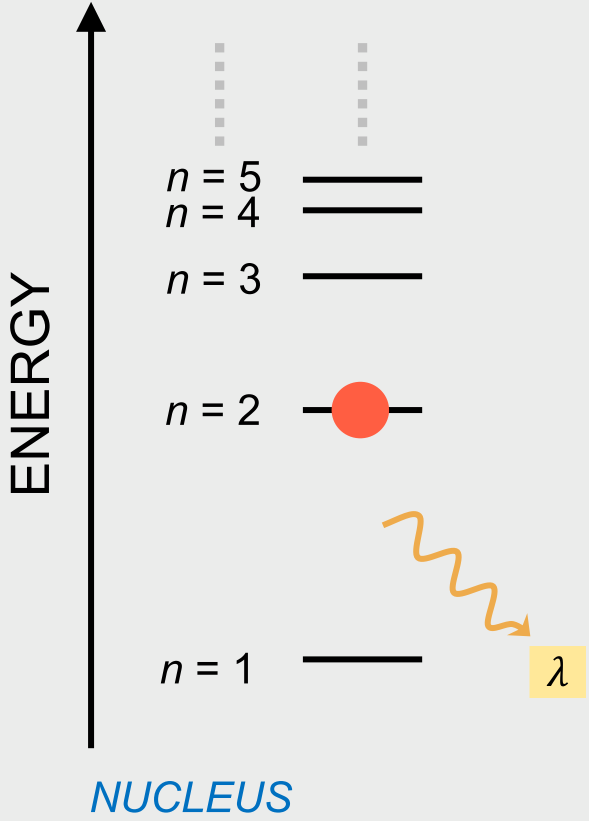
As an electron "relaxes" from a higher to lower energy level, it releases energy in the form of a photon of light with a specific wavelength.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_\mathrm{final}^2} - \frac{1}{n_\mathrm{initial}^2}\right] \quad ; \quad R = \frac{R_\mathrm{H}}{hc}$$



Today

Observe the same lines Balmer saw over a century ago. Make a few distance/length measurements, and use them to calculate the wavelengths for the three colors you observe.

↓

Use a Vernier Emission Spectrometer to measure the same wavelengths (plus one more).

↓

Show that your experimentally determined values do obey the Rydberg equation. Also, you will calculate the value of R.

Part 2

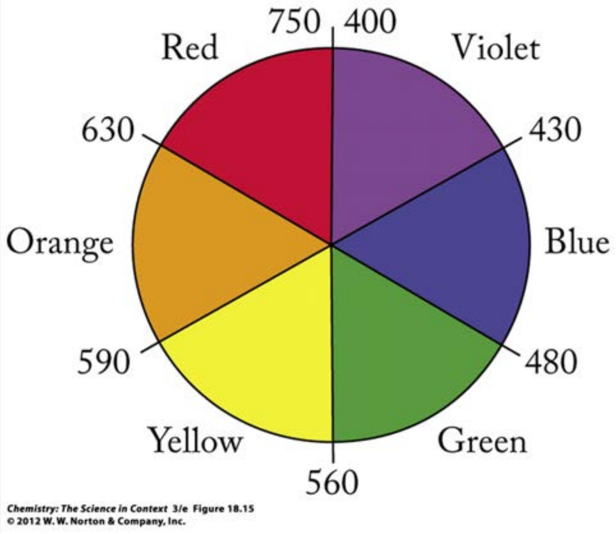
Light absorption and color of things

COMPLEMENTARY COLORS:

R/G　　O/B　　Y/P

If a chemical species is **RED**, it will strongly absorb **GREEN** light.

It may absorb other colors too.



Part 3

Mass Spectrometry

Isotopes and Isotopic Abundances

1 amu = 1/12 mass of 1 ^{12}C atom *exactly* (definition)

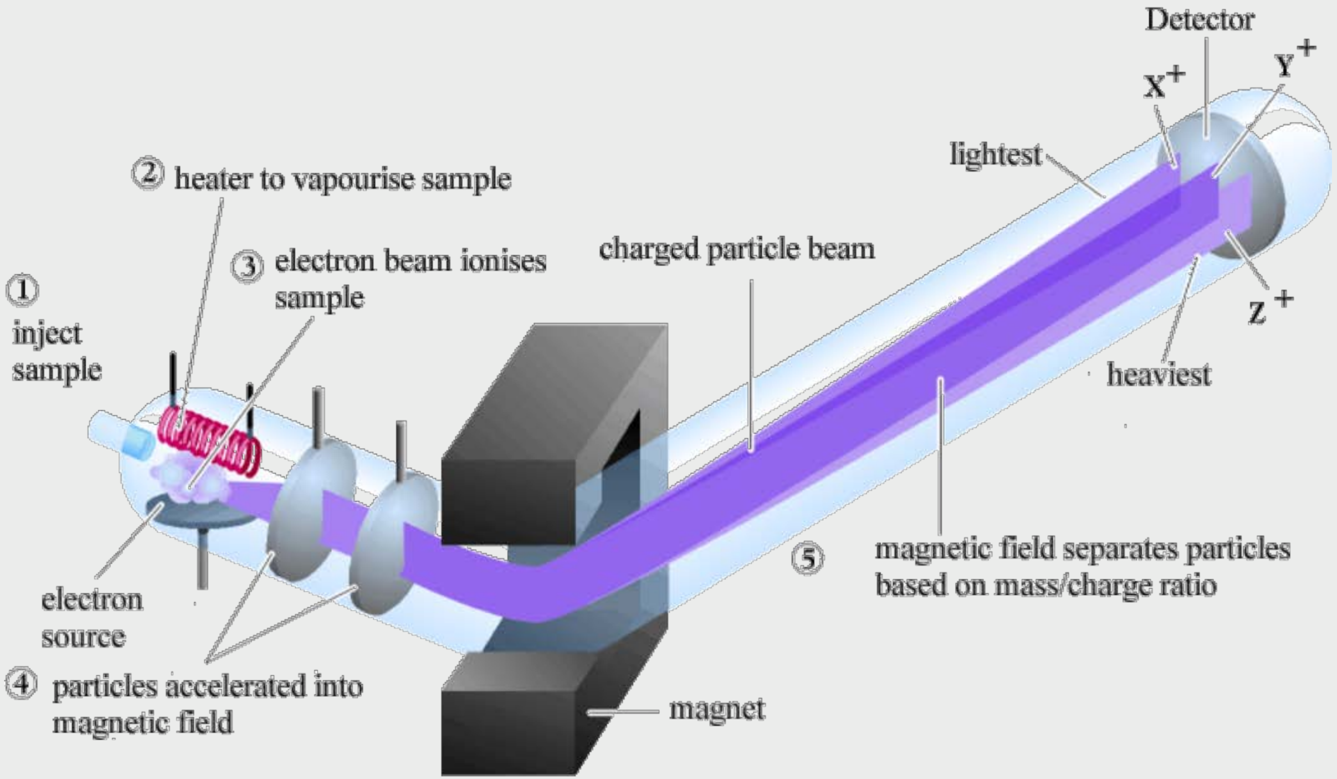
Fractional abundance of ^{12}C is 0.9893

Mass of 1 ^{13}C atom = 13.0035 amu

Fractional abundance of ^{13}C is (1 – 0.9893) = 0.0107

Average atomic mass of C = 12.0107 amu

Mass Spectrometry: How does it work?



Notes

1. Work the M&Ms quickly.
2. You will need a flash or thumb drive.
3. We have only one hydrogen lamp set-up. Take turns.