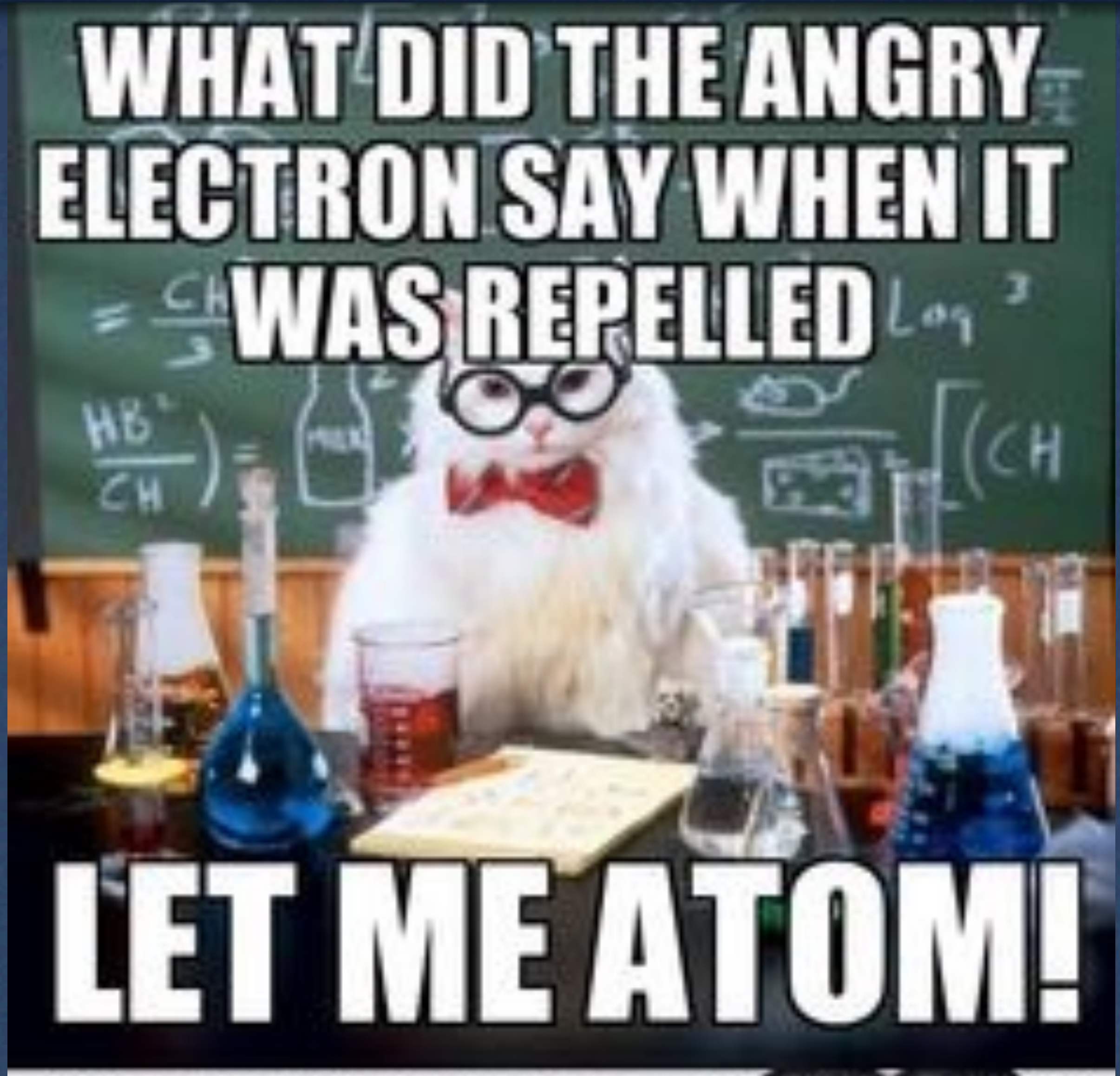


Electron Configuration

Tuesday 11/03/15

Agenda

- *Homework corrections - Finish*
- *Start subtopic on Electron Configuration*

Updates

- *I will have all tests, homework, classwork updated by this weekend.*
- *If you missed the exam you only have this week to make it up.*
- *I will not be in the tutoring center this week unfortunately.*

Topic 2.2
Electron configuration

- Emission spectra are produced when photons are emitted from atoms as excited electrons return to a lower energy level.
- The line emission spectrum of hydrogen provides evidence for the existence of electrons in discrete energy levels, which converge at higher energies.
- The main energy level or shell is given an integer number, n, and can hold a maximum number of electrons, $2n^2$.
- A more detailed model of the atom describes the division of the main energy level into s, p, d and f sub-levels of successively higher energies.
- Sub-levels contain a fixed number of orbitals, regions of space where there is a high probability of finding an electron.
- Each orbital has a defined energy state for a given electronic configuration and chemical environment and can hold two electrons of opposite spin.

Electron Configuration

The electromagnetic spectrum

- **Electromagnetic spectrum** consists of all wavelengths of light:
  - *gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves*
- Higher energy waves (gamma/x-rays) have **small** wavelengths where-as low energy radiation (radio/microwaves) have **longer** wavelengths.
- Wavelength and frequency are related through the following relationship:
  - $c = \nu \lambda$

E = joules
λ = meters (m)
ν = Hertz (Hz)
c = speed of light (3.00×10^8 m s^{-1})

Electron Configuration

The electromagnetic spectrum

Absorption, emission, and continuous spectra

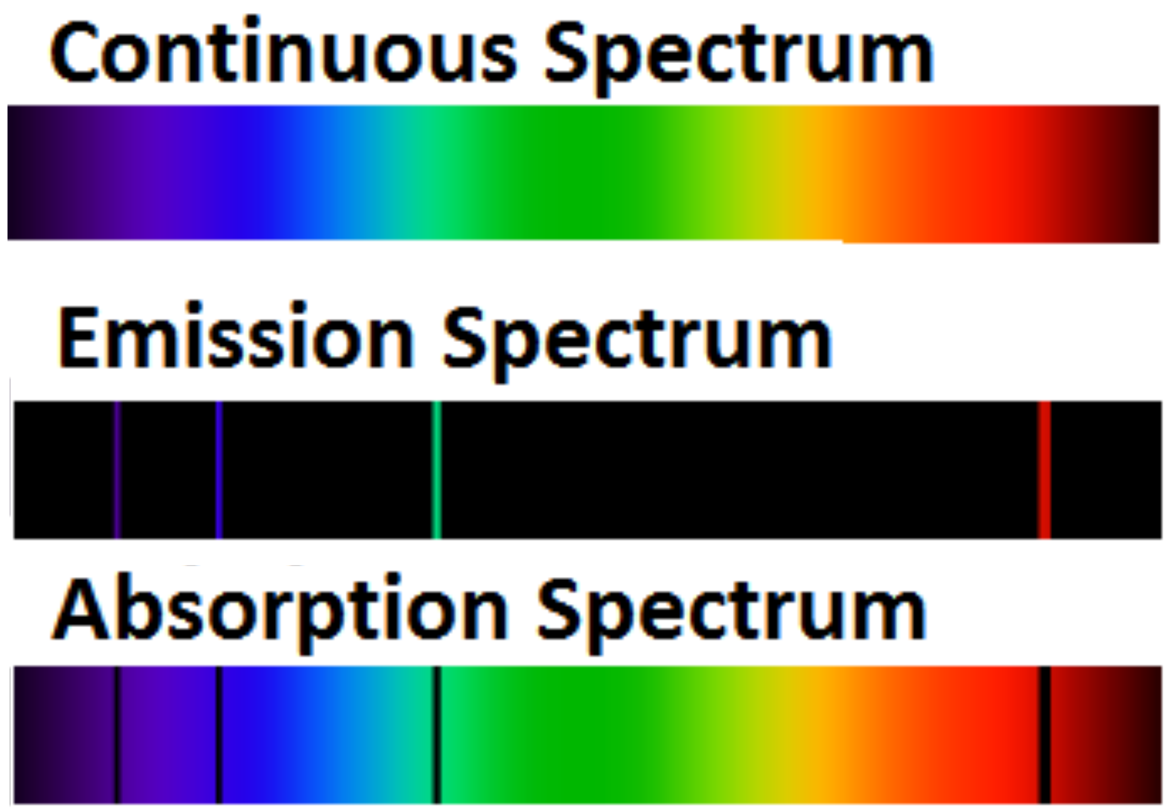
A white hot metal object emits the full range of wavelengths, producing a **continuous spectrum** including all the colors of the rainbow from red to violet.

i.e. white incandescent bulb

When a pure gaseous element is subjected to an electrical discharge, it will emit radiation. This results in an an **emission spectrum** which consists of a series of lines against a dark background.

i.e. hydrogen

If a cloud of cold gas is placed between a hot metal and a detector, an **absorption spectrum** is observed. This results in a pattern of dark lines against a colored background. The gaseous atoms absorb certain wavelengths of light from the continuous spectrum.



Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom

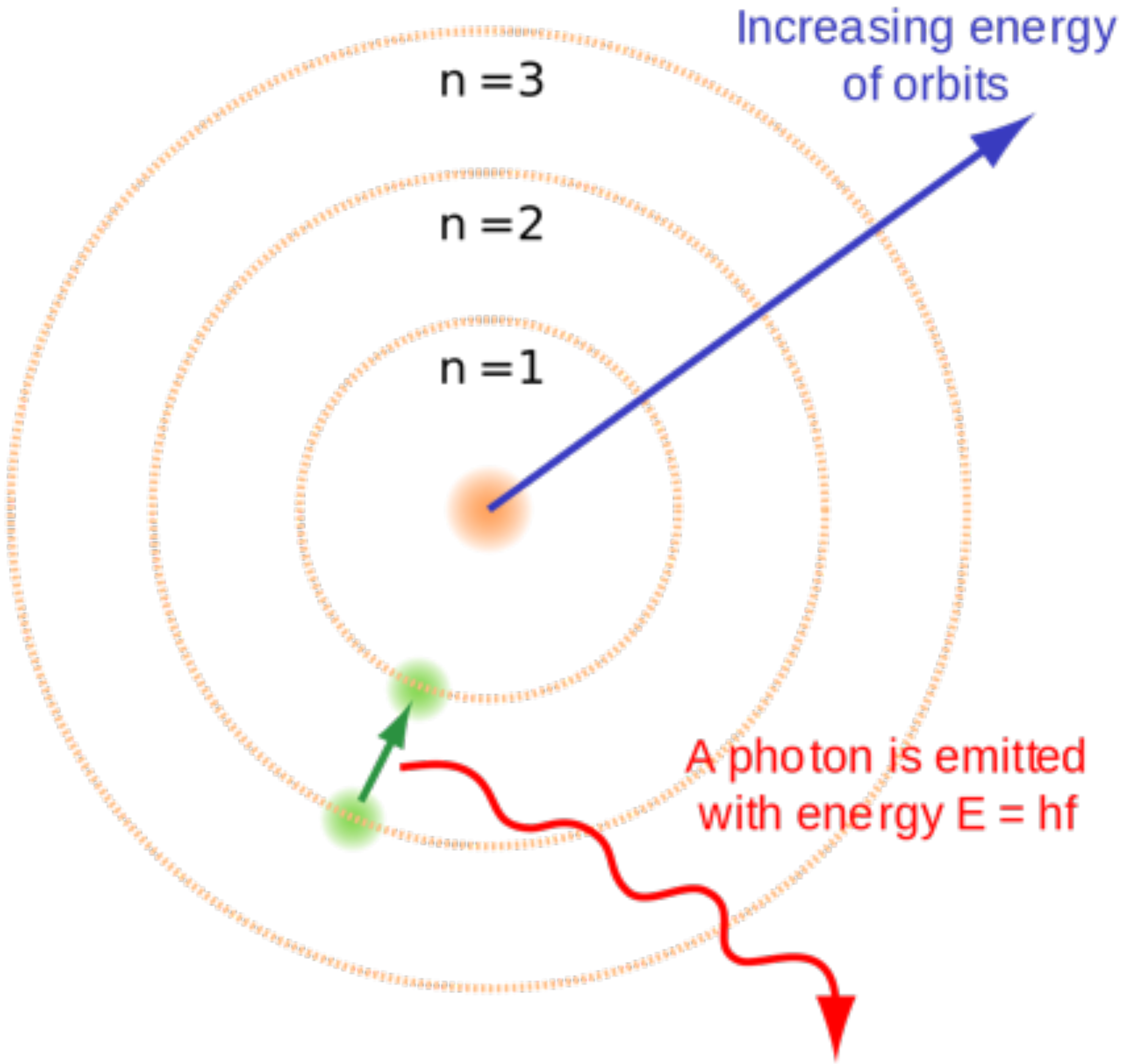
- Each element has its own characteristic line spectrum which is used to identify the element
- Lines in emission spectrum have specific wavelengths which corresponds to a discrete amount of energy
  - **Quantization**: Discrete "packets" of electromagnetic radiation
  - A **Photon** is a quantum of radiation
- $E = h\nu = hc/\lambda$ ⟶ *Energy of a photon*

h = Planck's constant = 6.63×10^{-34} *J s*
ν *= frequency of radiation*
c = speed of light = 3.00×10^{8} *m* s^{-1}

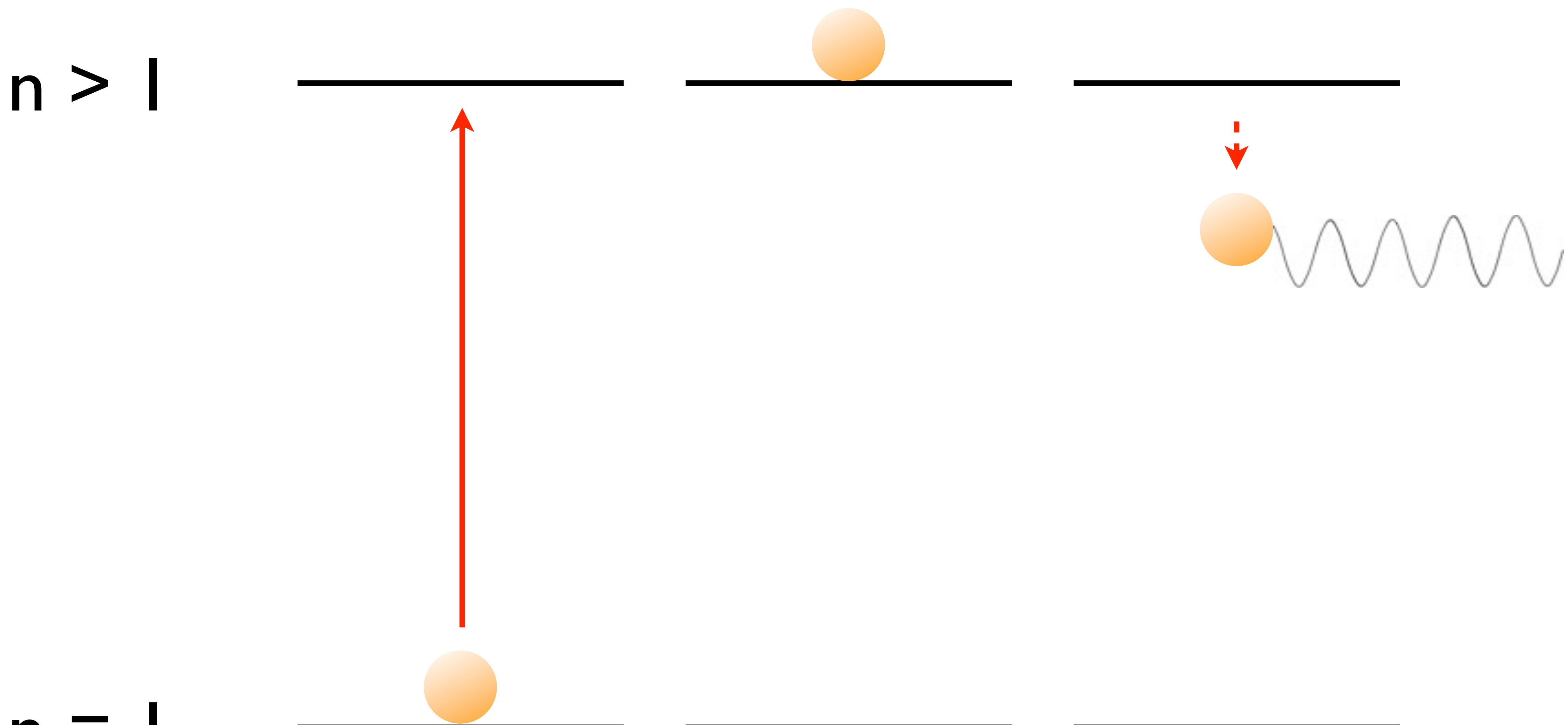
Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom

- When an electron in its **ground state** gets excited, it moves to a higher energy level and stays in this **excited-state** for a fraction of a second
- When the electron falls back from the excited-state to a lower level energy level it emits a **photon**, a discrete amount of energy. This corresponds to a particular wavelength depending on the energy difference between the two levels.

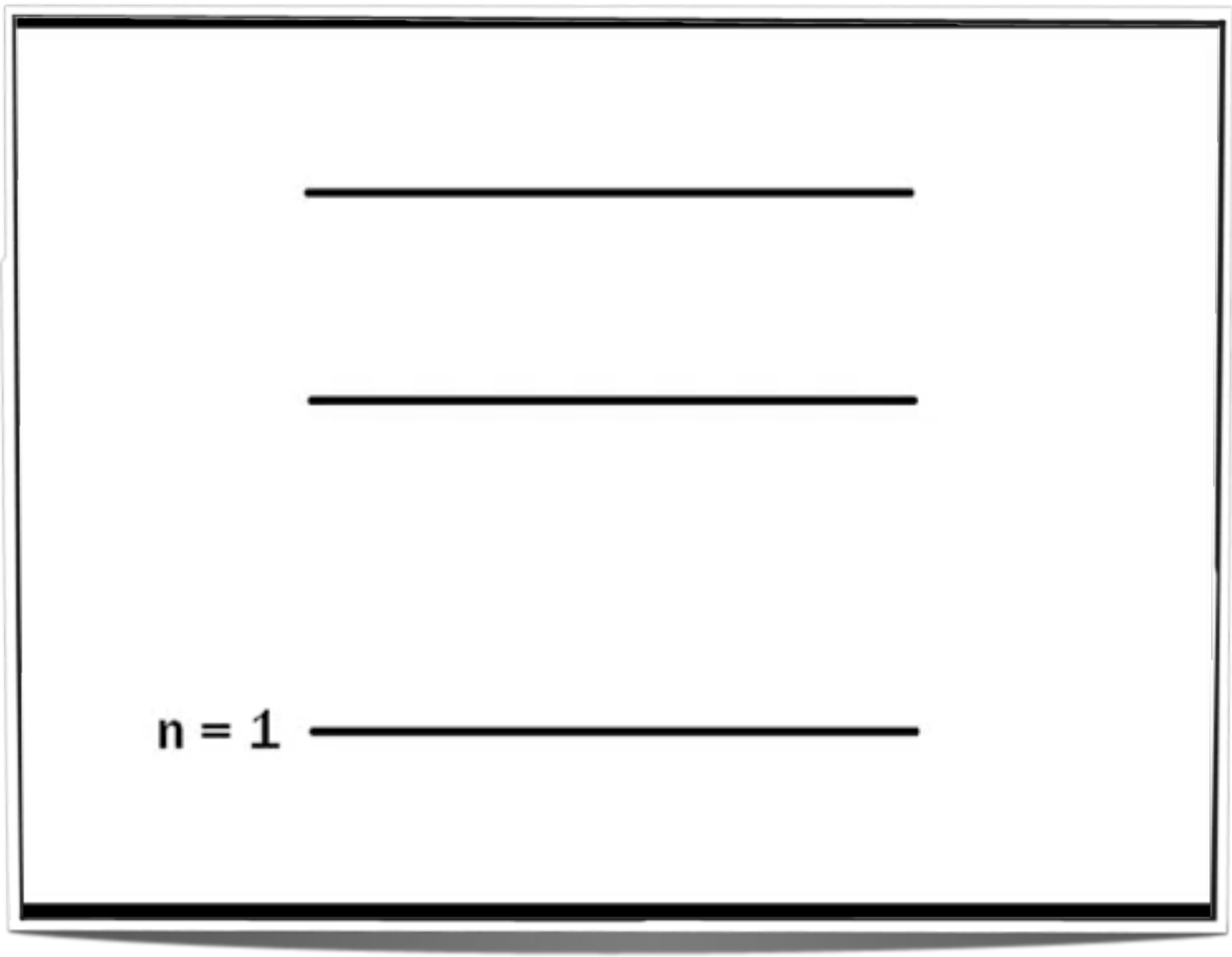


Principles of the Bohr model of an atom when an electron is excited. *n* is the principal quantum number



e- falls back down to a lower level and energy is emitted as a photon of light of wavelength, λ, corresponding to the energy difference between the two energy levels.

Atomic Emission Animation



Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom

- An electron can be excited to any energy level higher than its current level. They can also fall back down to any lower energy level.
- The difference in energy between the two energy levels can be expressed as follows

$$\Delta E = E_f - E_i$$

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

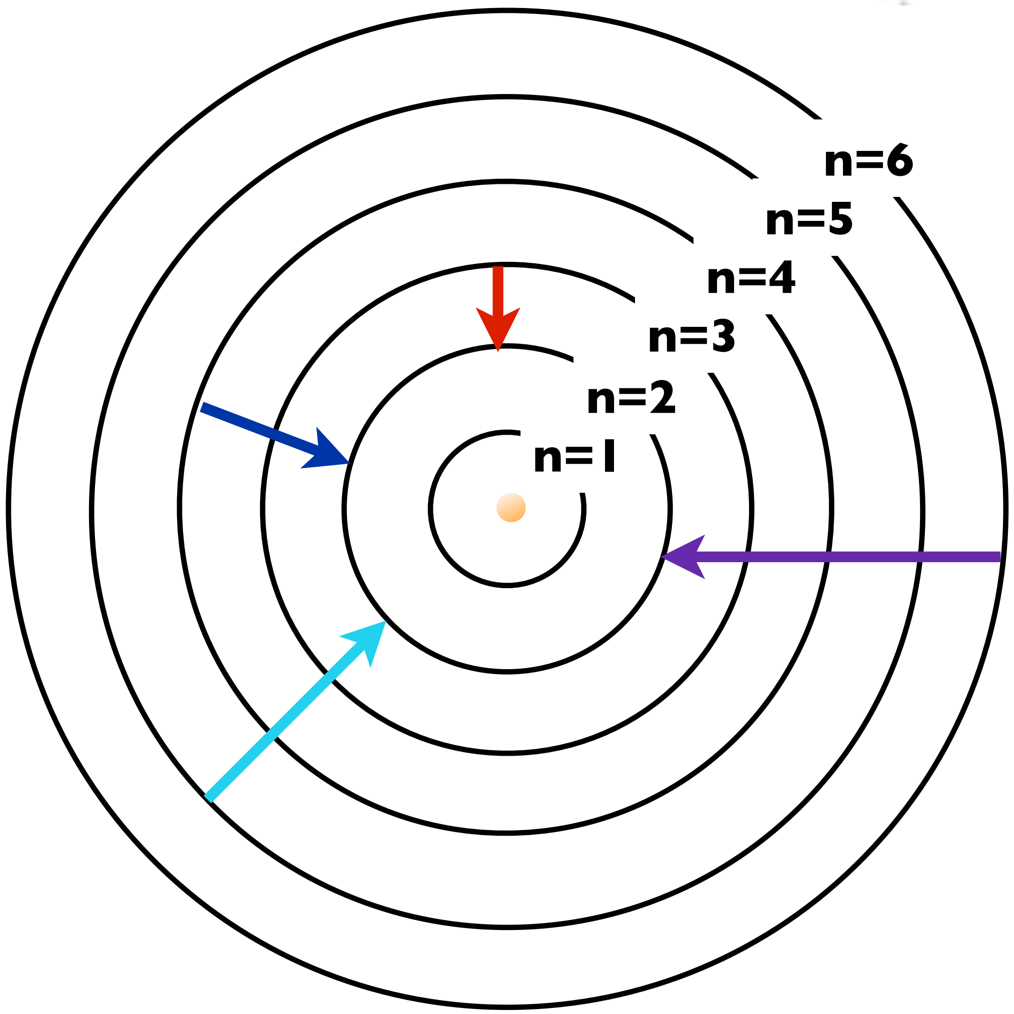
Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom

colour	violet	blue	blue-green	red
λ/nm	410	434	486	656
transition	n = 6 to n = 2	n = 5 to n = 2	n = 4 to n = 2	n = 3 to n = 2

Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom



Electron Configuration

Emission spectra and Bohr's theory of the hydrogen atom

Series	n_f	n_i	Region of EMS
Lyman	1	2,3,4,5, ...	UV
Balmer	2	3,4,5,6, ...	visible and UV
Paschen	3	4,5,6,7, ...	IR

Electron Configuration

Heisenberg's uncertainty principle

https://www.youtube.com/watch?v=TQKELOE9eY4

Electron Configuration

Heisenberg's uncertainty principle questions:

1. The wavelength of a quantum object is determined by its:
   a. Position
   b. Momentum
   c. Composition
   d. Multiple properties
2. For a quantum particle to have a long wavelength, it should have:
   a. Have a large mass and move at high speed
   b. Hard a large mass and move at low speed
   c. Have a small mass and move at high speed
   d. Have a small mass and move at low speed
3. Adding together multiple waves to make a wave packet means that:
   a. There are multiple particles in the packet, each with a different wavelength
   b. There are multiple particles in the packet, each with a different position
   c. The object has a single momentum but can be found in one of many positions
   d. The object has a single position but can be found in one of many momenta

Electron Configuration

Schrodinger's Cat

https://www.youtube.com/watch?v=UjaAxUO6-Uw

Electron Configuration

Schrodinger's equation questions:

1. We know quantum particles can occupy more than one state at the same time because:
   a. We find particles confined to a small region of space
   b. We see particles with well-defined momentum
   c. We see electrons interfering after passing through a double slit
   d. We see cats that are both alive and dead

2. We see wave behavior in electrons but not in cats because:
   a. Electrons move much faster than cats
   b. Electrons move much slower than cats
   c. Electrons are easier to control than cats
   d. Electrons have much lower mass than cats

3. An electron in the vicinity of two nearby atoms will be orbiting:
   a. The heavier of the two atoms only
   b. The lighter of the two atoms only
   c. Only one of the two atoms, but it's impossible to know which
   d. Both of the two atoms at the same time

Electron Configuration

Schrodinger's equation questions:

4. The behavior of electrons moving through solid objects is determined by:
    a. Electrons bouncing off atoms in the solid like billiard balls
    b. Electrons going around the outside of the solid like waves
    c. Electrons being shared between all of the atoms in the solid
    d. Electrons being pushed through the solid by other electrons

5. Quantum physics is important for computer technology because:
    a. The sharing of electrons between atoms determines the properties of semiconductors
    b. Internet messages are sent using the wave properties of electrons
    c. The flow of electrical current can only be understood in terms of waves
    d. The bits in a modern computer use single electrons

Electron Configuration

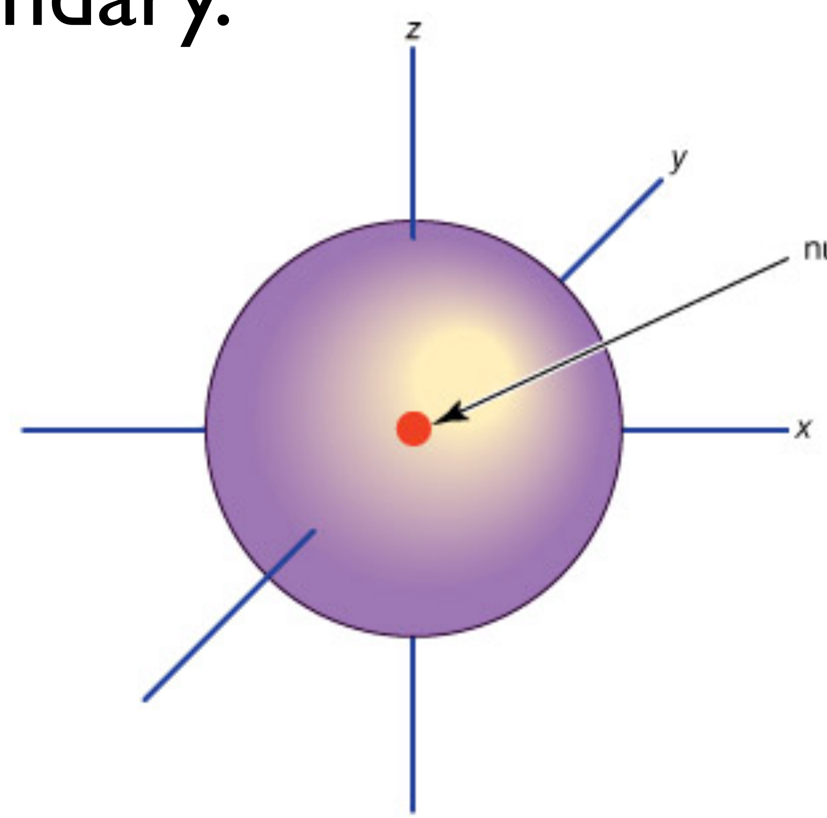
Schrodinger and atomic orbitals

- Schrodinger's work led to a series of mathematical functions called **wave functions** describing the electron in the hydrogen atom and associated possible energy states the electron can occupy.
  - Wave function represents the probability of finding an electron in a region of space at a given point in distance, *r*, from the nucleus. Known as **probability density**
- An **atomic orbital** is a region in space where there is a high *probability* of finding an electron.
  - Can hold a *maximum* of two electrons, with opposite spins
  - Types of orbitals: *s, p, d, f* ***(for SL only need to know s and p orbital shape)***
  - Each has a characteristic *shape* and associated *energy*

Electron Configuration

The atomic orbitals

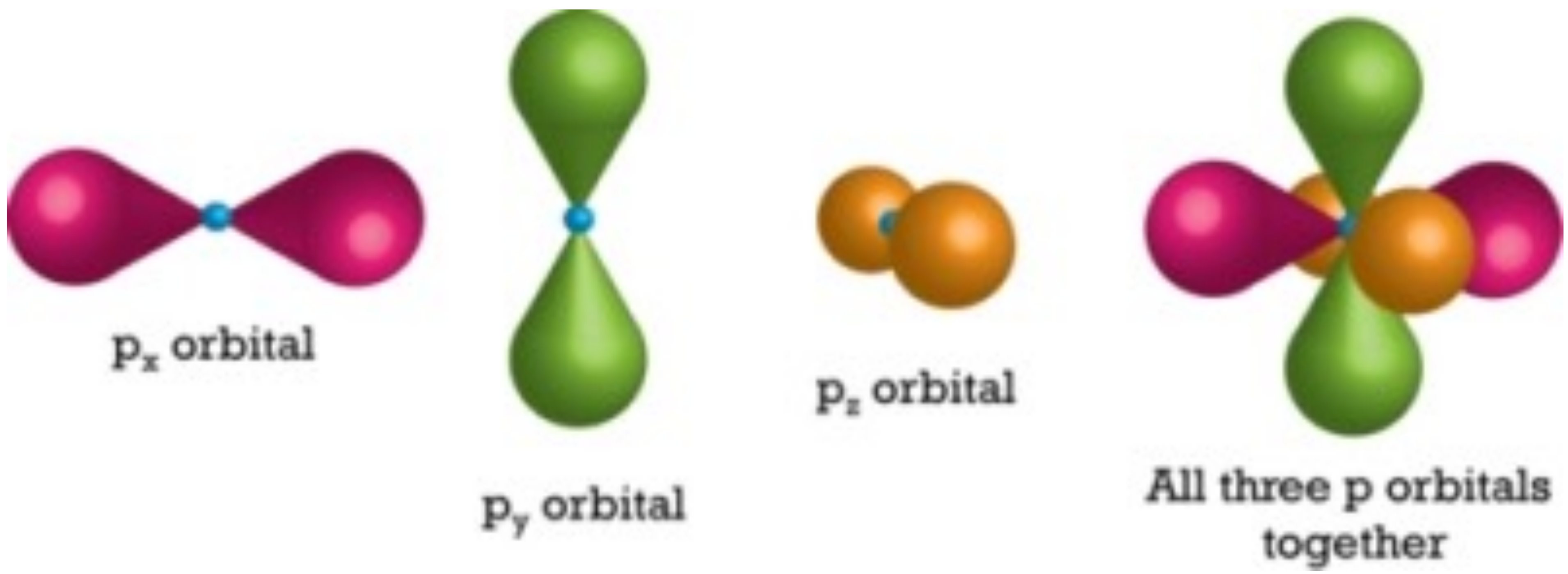
- **The s atomic orbital**
  - Spherically symmetrical
  - 99% chance of probability of finding an electron within the spherical boundary.



Electron Configuration

The atomic orbitals

- **The p atomic orbital**
  - Dumbbell shaped
  - Three p atomic orbitals p_x, p_y, p_z all with boundary surfaces conveying probable electron density pointing in different directions along the three respective Cartesian axes x, y, and z.



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