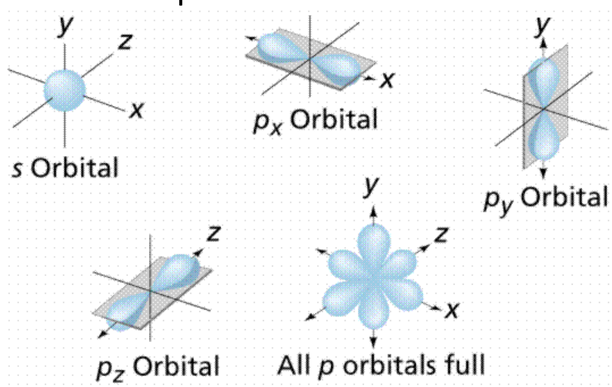
Ch 7 Extra Session Notes

Probability Waves of the Electron

- If electrons are waves, what do those waves look like?
- Strange kinds of waves… they are probability waves.
- Analogy for a probability wave, “Where is the teacher?” dot diagram
- Where is the electron? Psi^2 graphs (ψ^2) 1s, 2s, 2p, nodes
- How do these translate into 3-D patterns?



Atomic Orbitals

- These wave patterns are called “orbitals” in homage to the Rutherford model in which the electrons “orbited” the nucleus like the planets orbit the Sun.
- Each of these orbitals overlap the others.

	s	p	d	f
4	○	○○○	○○○○○	○○○○○○○
3	○	○○○	○○○○○	
2	○	○○○		
1	○			

- In hydrogen, the electron can be in any of these wave patterns. The wave pattern “exists” whether there is an electron in it or not. Analogy: Holding Patterns for Airplanes around LAX.
- Link to the Balmer Series for the hydrogen line spectrum: red line means n=3 $\rightarrow$ n=2 which means 3s $\rightarrow$ 2s or 3d $\rightarrow$ 2p or 3s $\rightarrow$ 2p, etc.
- All “3” orbitals in hydrogen have the same energy as each other. All “2” orbitals have the same energy as each other in hydrogen. This will not be true for all other elements.

Quantum Numbers

- These wave patterns are mathematical. Mechanics is the collection of mathematical equations that describes something. Quantum mechanics is the mathematical equations that describes the quantized world of atoms and electrons. There are variables in these equations and we call them "quantum numbers". We have already seen one of these, "n".
- We have already seen one of the mathematical equations, $E_n = -Rhc/n^2$
- Three quantum numbers describe an orbital:
  - n (the principal quantum number) describes the **energy** of the orbital.
  - ℓ (the angular momentum quantum number) sets the shape or type of the orbital.
  - m_ℓ (the magnetic quantum number) sets the orientation of the orbital (e.g. x, y, z).
- There are rules for these quantum numbers.

  n = 1, 2, 3, … etc.

  ℓ can be $0 \rightarrow n - 1$

  m_ℓ can be $-\ell \rightarrow +\ell$
- This is like a "game" and you need to learn the rules and be able to play the game. Example: What are the three quantum numbers that define the **5d** orbital.

The Photoelectric Effect

- We saw particle-wave duality when we said that electrons must be waves because they have quantized energy levels. However, we know that electrons are particles.
- We were using particle-wave duality when we calculated the de Broglie wavelengths of moving objects ($\lambda = h/mv$).
- Another example of particle-wave duality is the phenomena called "the photoelectric effect". Officially, this has been shown with UV light and Zn metal. We will show this with zinc sulfide (glow in the dark plastic) and visible light.
- The phenomena is that the electrons are excited to higher energy states (or ionized completely in the case of metal) by a certain energy of light. The excitation depends on the frequency of light, not the brightness of light. This means that the TOTAL energy is not important (a green laser had more TOTAL energy than a little blue flashlight). The excitation must depend on the energy PER PARTICLE of light. That is, Light must come in PARTICLES (photons). But we know that light exists in waves. Wave Particle duality again. Albert Einstein earned his Nobel Prize in 1921 "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect".
- Analogy: The PBS Pledge Drive, the Cowbell, and TOTAL amount versus the amount PER DONATION.