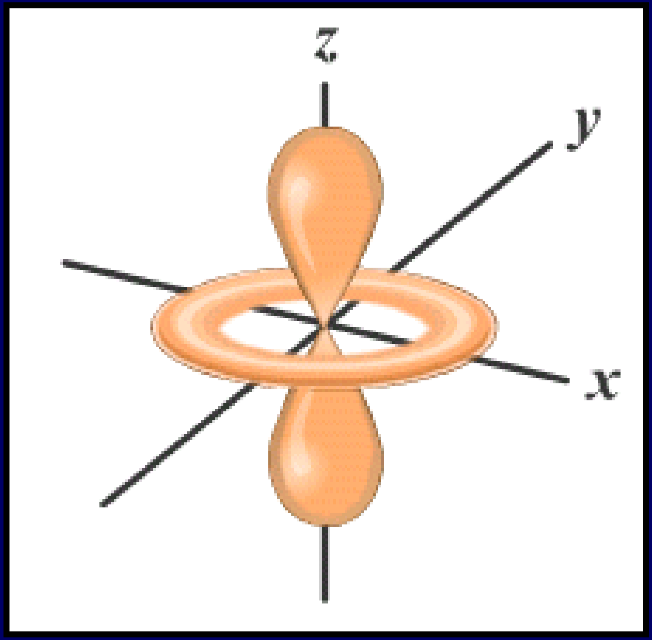
Unit 4 - Electrons in Atoms



III. Quantum Model of the Atom

(p. 98 – 104 in class)

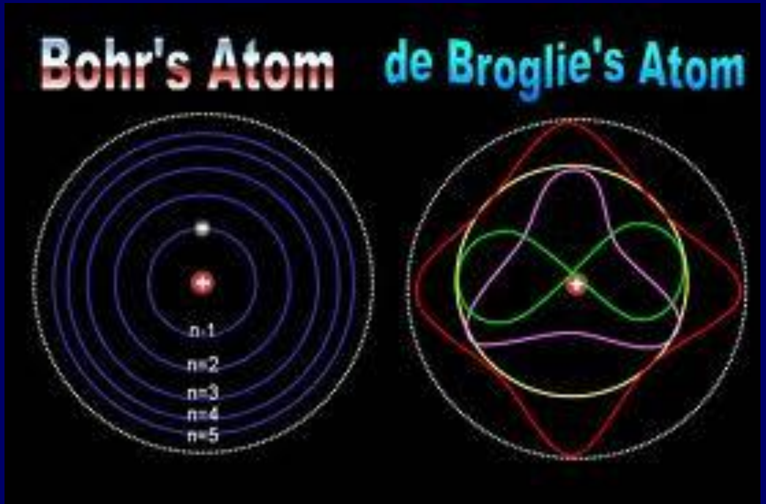
The Quantum Model

Because of the many questions left about Bohr's model of the atom, scientists had to change the way they viewed the nature of an electron

A. Electrons as Waves

⌘**Louis de Broglie** (1924)

- Applied wave-particle theory to e^-
- He pointed out that in many ways the behavior of Bohr's quantized e^- orbits were similar to the know behavior of waves.



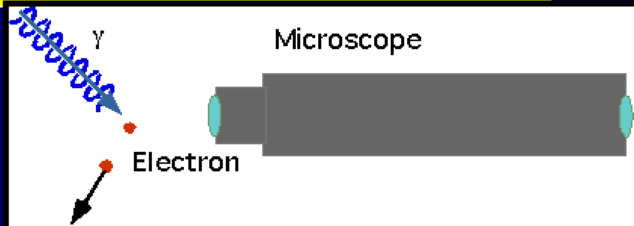
A. Electrons as Waves

He Concluded: Like ripples as a rock hits a pond's surface - electrons can be look at like waves around the atom's nucleus

- If this is true then electrons can only exist at specific frequencies
- By using $E = h\nu$ he was able to show that these electron waves had frequencies that corresponded to specific energies → the quantized energies of Bohr's orbits.

B. Quantum Mechanics

- **Heisenberg (1927) - worked to detect electrons by their interaction with photons.**
- Concluded that there is always an uncertainty in trying to locate an e^-
  - **Uncertainty Principle: It is impossible to know both the velocity and position of an electron at the same time**



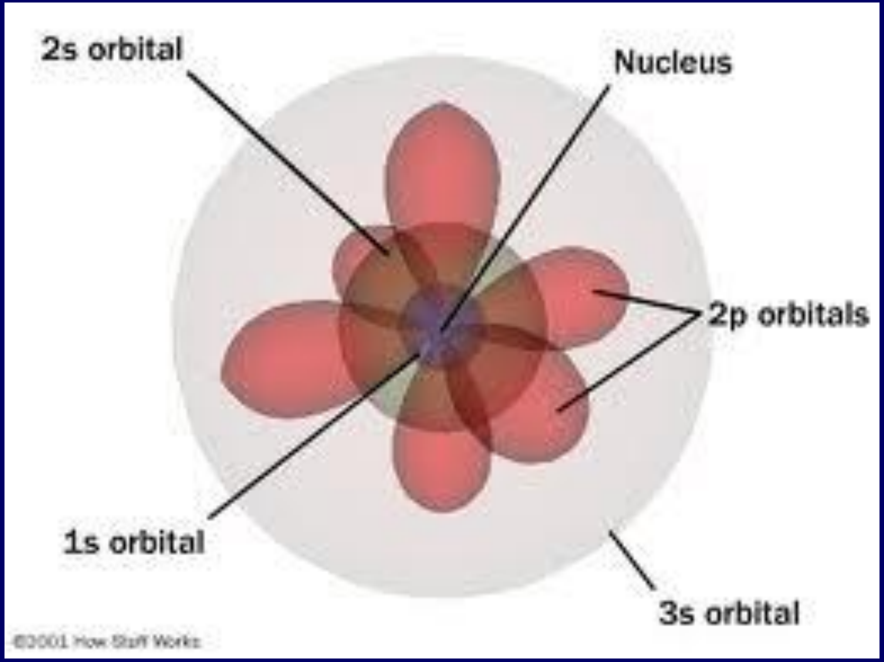
B. Quantum Mechanics

- **Schrödinger Wave Equation** (1926)
  - He used de Broglie's hypothesis and devised an equation that treated the electrons moving around the nucleus as waves
  - His equation defines probability of finding an e^-

$$\Psi_{1s} = \frac{1}{\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} e^{-\sigma}$$

B. Quantum Mechanics

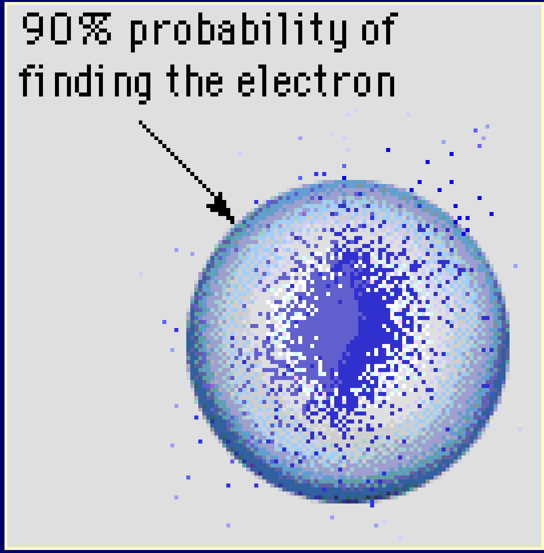
- **Schrödinger**'s model: the nucleus is surrounded by what is described as orbitals
- Orbital: a three-dimensional region around the nucleus



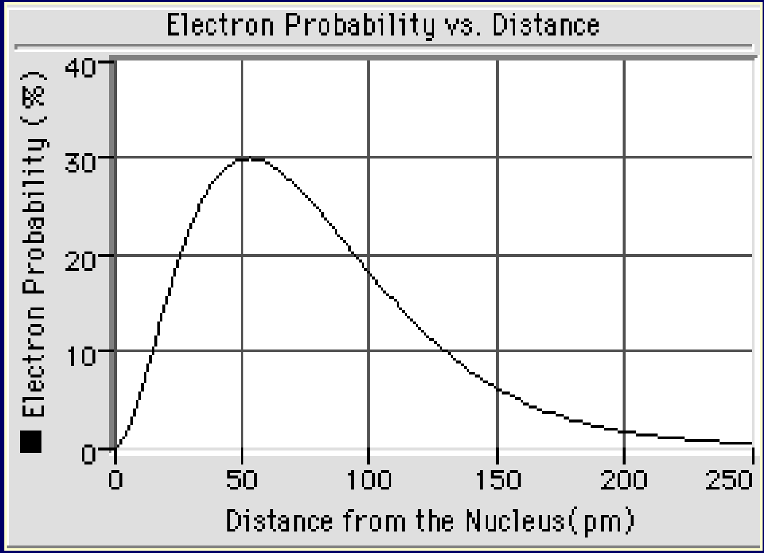
B. Quantum Mechanics

⌘**Orbital** ("electron cloud")

- Region in space where there is 90% probability of finding an e^-



Orbital

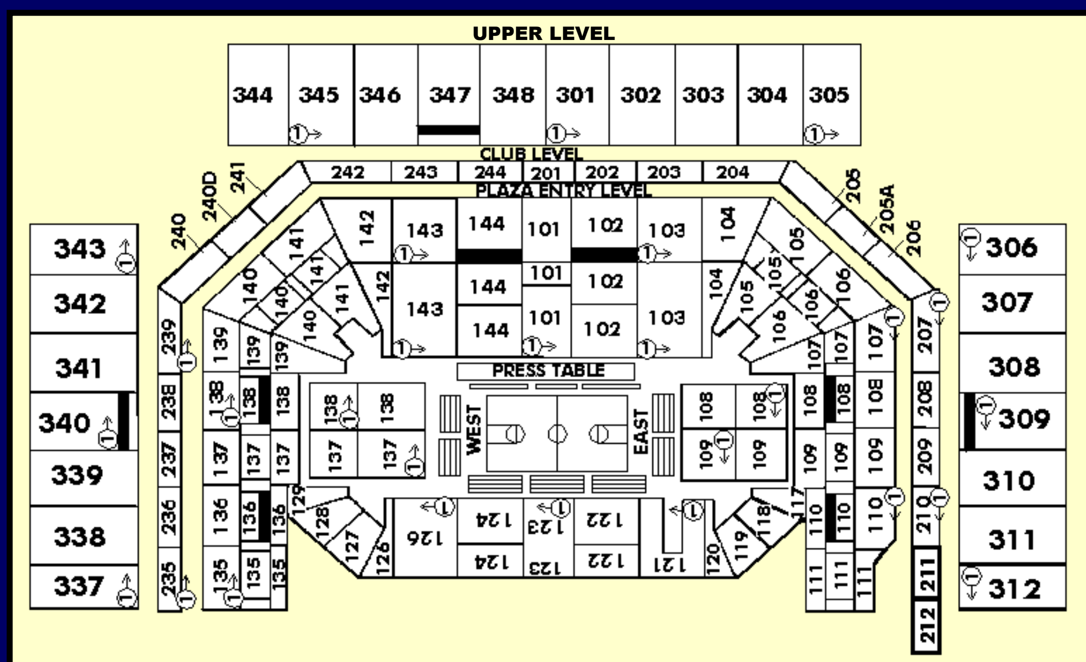


Radial Distribution Curve

C. Quantum Numbers

⌘**Four Quantum Numbers:**

- Specify the “address” of each electron in an atom



C. Quantum Numbers

⌘Pauli Exclusion Principle

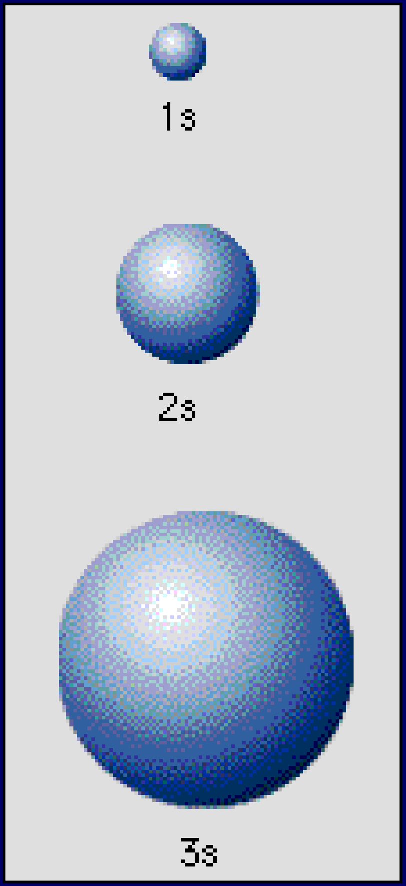
No two electrons in an atom can have the same 4 quantum numbers.

- Each e^- has a unique “address”:

C. Quantum Numbers

1. Principal Quantum Number *(n)*

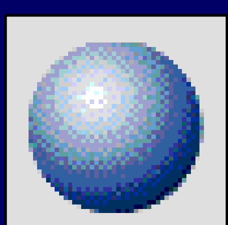
- Energy level
- Size of the orbital
- n^2 = # of orbitals in the energy level



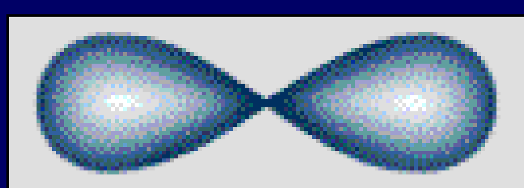
C. Quantum Numbers

2. Angular Momentum Quantum # (*l*)

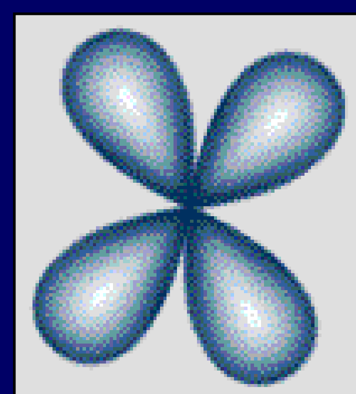
- Energy sublevel
- Shape of the orbital



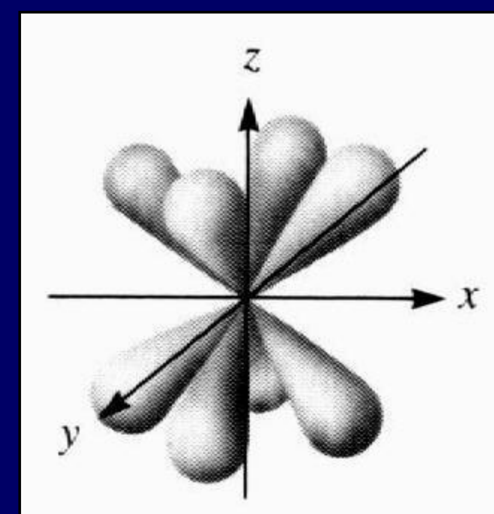
s



p

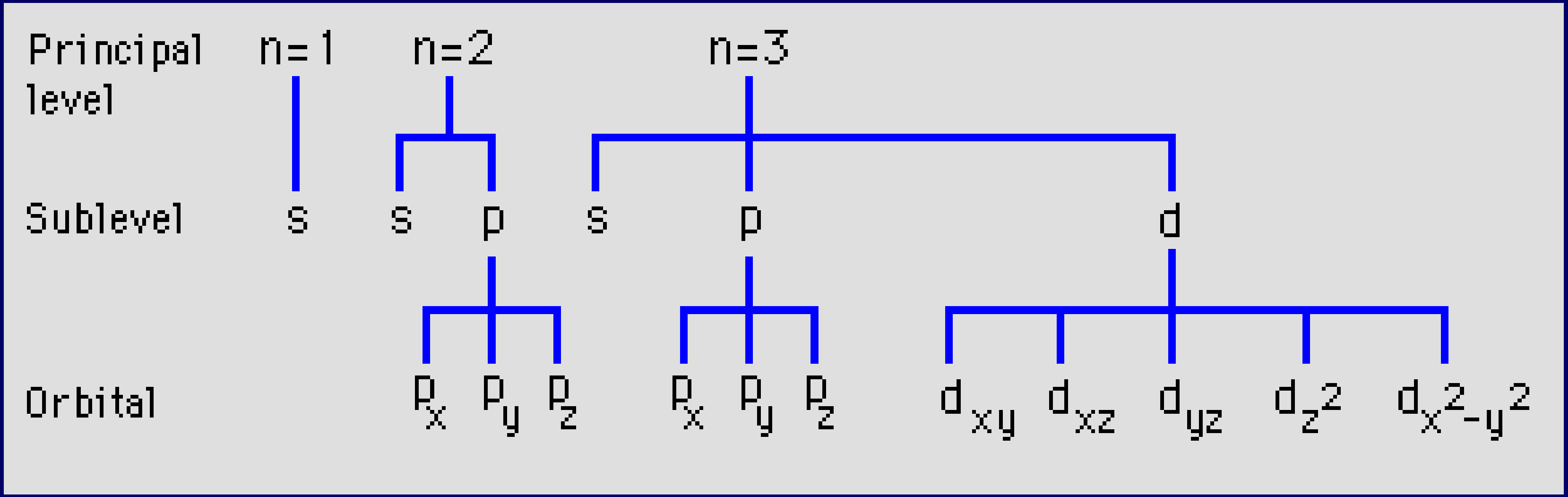


d



f

C. Quantum Numbers

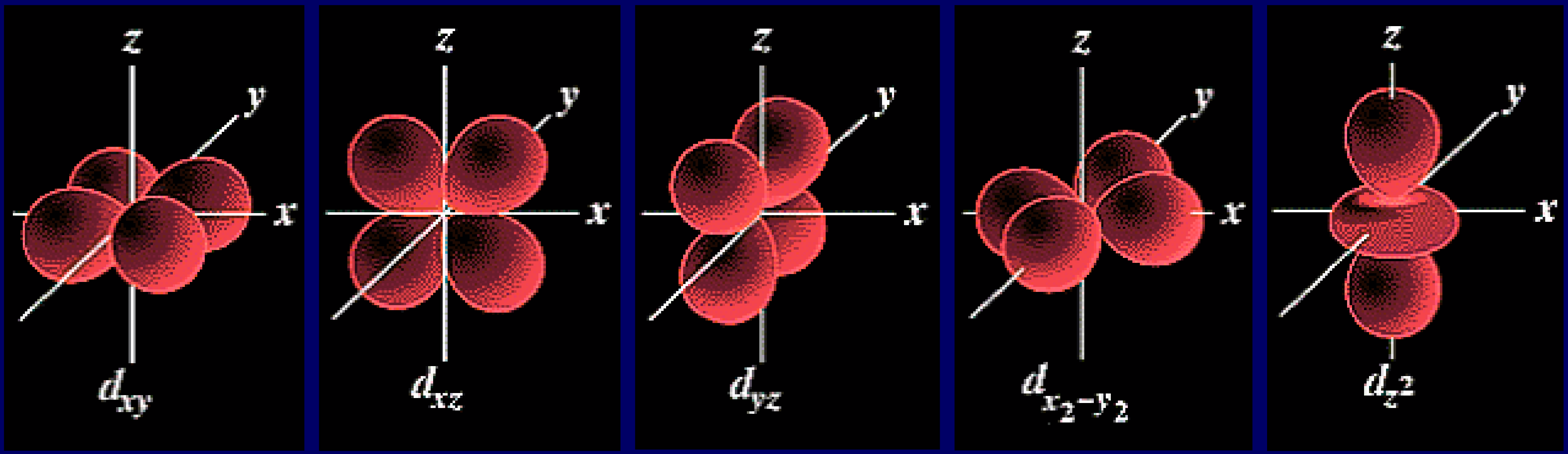


- n = # of sublevels per level
- n^2 = # of orbitals per level
- Sublevel sets: **1** s, **3** p, **5** d, **7** f

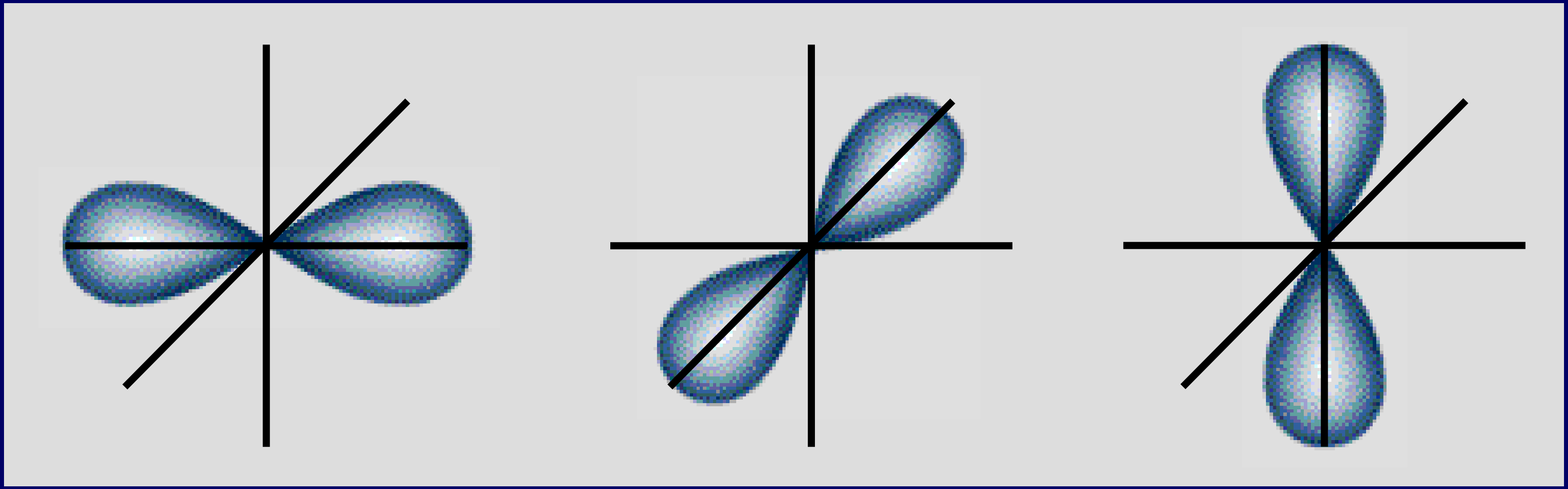
C. Quantum Numbers

3. Magnetic Quantum Number (m_l)

- Orientation of orbital
- Specifies the exact orbital within each sublevel



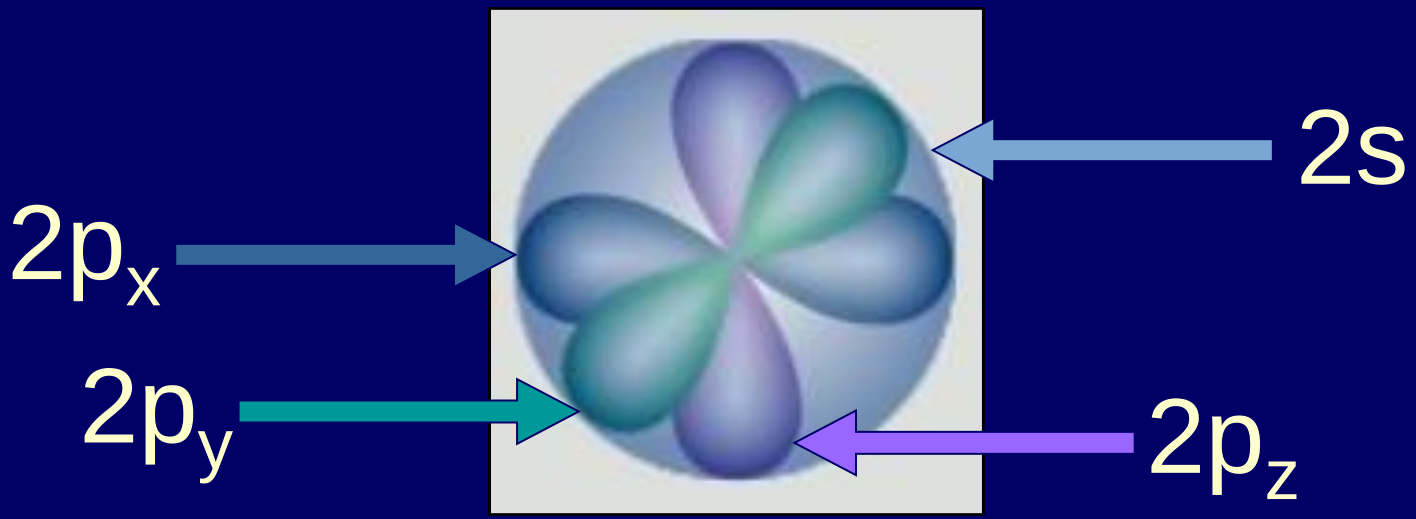
C. Quantum Numbers



p_x p_y p_z

C. Quantum Numbers

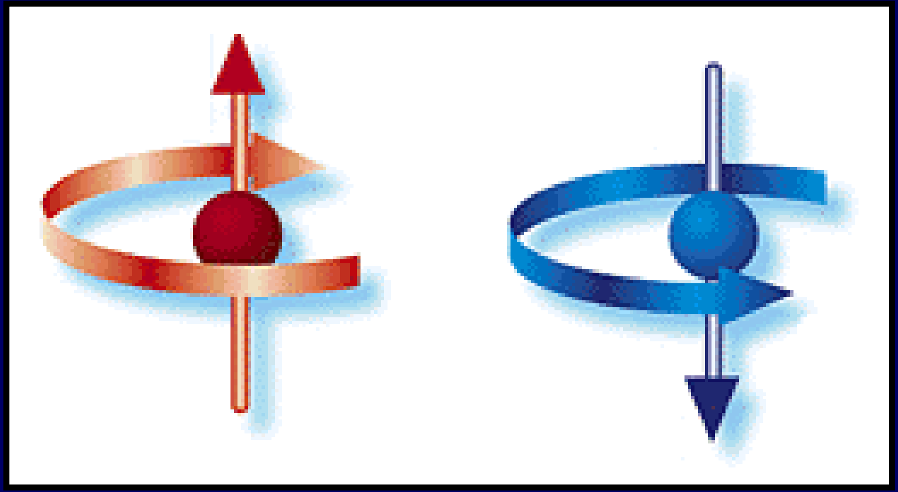
- Orbitals combine to form a spherical shape.



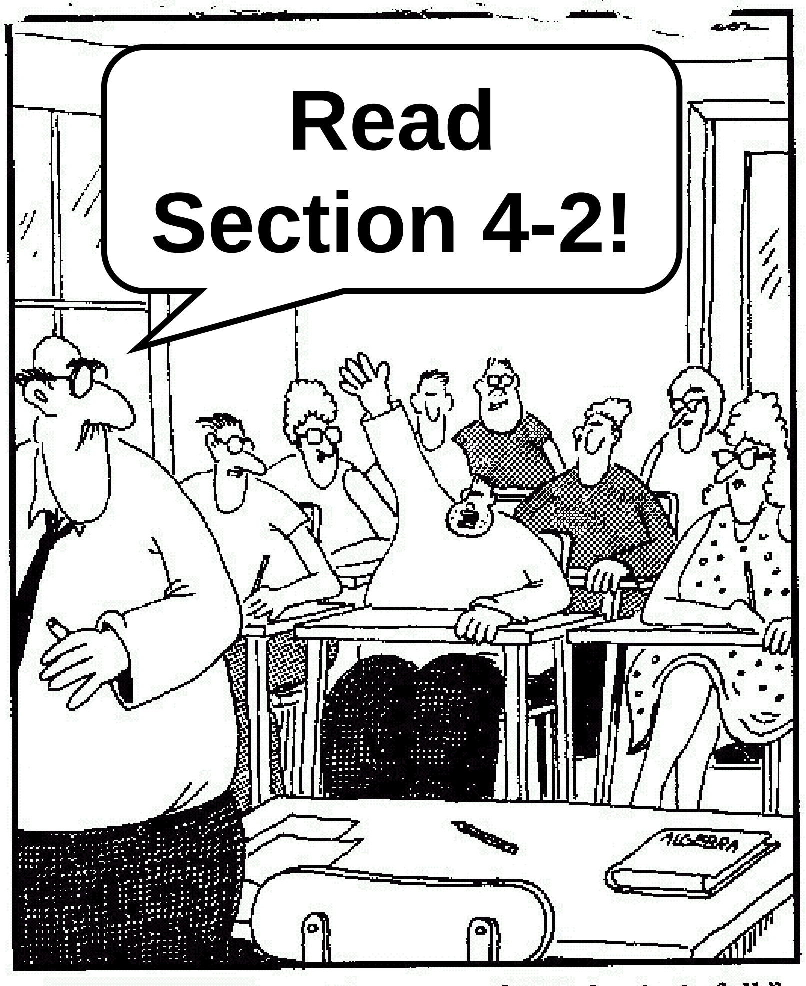
C. Quantum Numbers

4. Spin Quantum Number (m_s)

- Electron spin $\Rightarrow$ +½ or -½
- An orbital can hold 2 electrons that spin in opposite directions.



Feeling overwhelmed?



Dr. Callaway, may I be excused? My brain is full."